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Title: DEVELOPMENT AND TESTING OF ELCAS RO/RO

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INTRODUCTION

Background

The Naval Civil Engineering Laboratory (NCEL) has developed hardware that will provide the Navy with the capability of connecting the floating Causeway Platform Facility (CPF) of the Roll-On/Roll-Off Discharge Facility (RRDF) to the seaward end of an Elevated Causeway (ELCAS). The advantages sought by this capability are to decrease the transit time of lighterage moving from ship to shore, to enable the lighterage to bypass the surfzone, to centralize the throughput on the beach, and to provide the capability to offload roll-on/roll-off (RO/RO) cargo where shallow gradients would prevent lighterage from reaching shore.

Development and testing of the ELCAS RO/RO concept was funded by the Naval Facilities Engineering Command (NAVFAC) Sealift Support Division (Code 061) under the advanced development (6.3) program. The prime objective was proof of design concept rather than the development of hardware for service use.

Scope

This report documents the development and testing of the ELCAS RO/RO concept from the design and fabrication of the ramp interface hardware and CPF mooring system to the installation and operation of the system during ELCAS operations at Fort Story, Virginia.

ELCAS RO/RO SYSTEM DEVELOPMENT

The ELCAS RO/RO concept makes use of the Lightweight Multi-purpose Modular Spanning Assembly (LMMSA) as the ramp between the ELCAS and the floating CPF (Figure 1). The LMMSA system developed under contract to the Navy included interface hardware between the ELCAS and CPF; however, prior testing of the hardware at the Amphibious Construction Battalion Two (ACB-2) facility in September 1988 indicated that it was unsatisfactory for the operational requirements of the ELCAS RO/RO application. Because the CPF was not designed to be used in conjunction with an ELCAS, the CPF's mooring arrangement off the end of the ELCAS also needed to be addressed. The ELCAS RO/RO system required validation during operational tests which were supported by ACB-2 in two phases. The first phase included testing of the LMMSA interface hardware in ACB-2's Desert Cove, and the second phase included full operational tests during an ELCAS installation where the CPF was moored off the seaward end of the ELCAS and the LMMSA was installed between the CPF and ELCAS.

Design. The ELCAS RO/RO operational objectives included the following:

- discharge of RO/RO cargo to have minimal interference with normal ELCAS operations;
- be operational in the same sea state conditions as the RRDF; and
- be capable of rapid installation and retrieval.

LMMSA Interface Hardware. The original LMMSA hardware included interface hardware for a pier to floating platform concept, which was operationally unsatisfactory. The LMMSA/ELCAS interface consisted of two upper bearing assemblies that were anchored to the deck of the ELCAS then pinned to the LMMSA (Figure 2). This pin connection proved difficult operationally and the strength and movement allowed by the rubber pads were marginal. The LMMSA/CPF interface consisted of a low friction skate assembly to which the LMMSA was pinned (Figure 3). Hilman rollers on the skate assembly allowed longitudinal movement of the LMMSA on the deck to accommodate CPF motions. During the tests the PHIBCB's had difficulty controlling the LMMSA footing because of the easy movement allowed by the rollers. The rollers also were spaced at such a distance that the bolt heads on the causeway angles interfered with their movement. To overcome these problems, a redesign of the interface hardware was required. The LMMSA/ELCAS interface should allow the ramp to accommodate pitch, roll, and heave motion of the CPF, and the LMMSA/CPF interface should permit CPF movement but provide more resistance than the Hilman rollers.

LMMSA/ELCAS Interface. The LMMSA/ELCAS interface (Figure 4) consists of two supporting beams that mate via a kingpin similar in design to the LST bow ramp. The bridge beam pins to the bottom of the LMMSA and has a protruding six inch diameter pipe for the kingpin (Figure 5). The foundation beam is welded to the ELCAS deck on top of the shear connectors and has a receiver that mates with the kingpin on the bridge beam (Figure 6). This kingpin system allows the ramp to accommodate pitch, roll, and heave motion of the CPF. The LMMSA/CPF interface also consists of two rubber fenders that dampen roll motion of the ramp while traffic is moving over it. Up to 20,000 pound uplift force is controlled by shackling each end of the beams together. The beams were designed to support the load of a 130,000 pound tank. The LMMSA/ELCAS Interface design was completed at NCEL (Refs 1 through 4).

LMMSA/CPF Interface. The LMMSA/CPF interface makes use of the same supporting foundation as the original interface hardware but substitutes stainless steel skates for the Hilman rollers (Figure 7). The skates slide on wax coated timber dunnage placed evenly on the deck of the CPF. The wax reduces the friction between the skate and dunnage so that the skates move with some resistance but do not move in response to wave action or changes in trim of the CPF.

The skates were designed to the same base plate and height dimensions of the Hilman rollers to make for an easy field substitution and the transition finger ramps would not be affected. The only modification required on original LMMSA hardware was the drilling of additional holes in the supporting foundation. The LMMSA/CPF Interface design was completed at NCEL (Refs 1 through 4).

Mooring of the Causeway Platform Facility (CPF). To provide a RO/RO capability to the ELCAS, the floating CPF would have to be moored off the seaward end of the ELCAS - a configuration not within the ELCAS and RRDF's present capability. NCEL investigated several mooring designs (Ref 5), and when presented to ACB-2, an alternate mooring system was agreed upon. The final configuration consists of two outboard end lateral anchors, two breasting and two criss-cross lines from the CPF to the ELCAS, and two RO/RO fenders on the CPF bearing upon piles driven at the end of the ELCAS (Figure 8). The piles would be supported by two pile restraint guides welded to the ELCAS deck. A three section wide ELCAS pierhead is required for this mooring configuration.

A four point stand-off mooring was considered; however, there was concern about the ability to sustain the CPF in a tight watch circle. Other perceived difficulties, such as construction of LMMSA on the CPF and LMMSA installation and retrieval weighed against the stand-off moor. The selected contact moor eased some of these problems.

Fabrication. The LMMSA interface hardware was fabricated in the Technical Support Division at NCEL. Material costs for the LMMSA/ELCAS and LMMSA/CPF interface hardware was approximately $11,000. A total of 600 man hours was required to fabricate the bridge beam, foundation beam, and skate assemblies; however, the total labor hours could have been reduced if wire feed welding equipment had been available.

The pile restraint guides as well as miscellaneous hardware required during the tests were manufactured at ACB-2.

PHASE I TEST

The purpose of the ELCAS RO/RO Phase I test was to validate the LMMSA interface hardware design and to demonstrate the feasibility of erecting the LMMSA as a ramp between the CPF and an ELCAS. The Phase I testing took place in ACB-2's Desert Cove in May 1990 and was performed for two specified standoff distances of the CPF from the end of the ELCAS.

LMMSA Assembly. A two section floating causeway (one wide) was used to simulate the CPF for Phase I testing. A P&H Omega 65-ton hydraulic crane on the dock was used to erect the LMMSA (Figure 9) on the causeway. The first LMMSA module offloaded for assembly was a ramp section. This ramp section was opened and braced before being pinned to the LMMSA/ELCAS bridge beam. The ramp module was then lowered onto 8"x 8" dunnage on the causeway deck so that the bridge beam just overhung the end of the causeway (Figure 10). The first LMMSA parallel module was opened then lowered to the causeway deck, where the crane was used to connect it to the end of the LMMSA ramp module. The three remaining parallel modules were then connected in similar fashion. The second LMMSA ramp module was opened, braced, then lowered to the causeway deck (Figure 11) where the skate assemblies were pinned on. This ramp module was then connected to the last parallel module.

During this assembly the LMMSA module lifting beam could not lift either LMMSA ramp module with the bridge beam or skate assembly attached because the unbalanced lift overloaded two of the legs of the sling. A four part sling produced an uneven lift angle as well, indicating the need for a sling arrangement with longer lengths for each of the heavy end legs.

Six Foot Standoff Moor. Two land-based causeways were stacked at the end of the causeway launching slip to simulate an ELCAS (Figure 12). The LMMSA/ELCAS foundation beam was welded on top of the shear connectors of the top land-based section. The two section floating causeway was then moored in the causeway launching slip. A six foot separation between the floating causeway and land-based causeways simulated the CPF being moored at the end of the ELCAS using RO/RO fenders bearing against piles driven at the ELCAS end. The ELCAS 140-ton mobile crane was positioned next to the land based causeways for the LMMSA lift. The bridge lifting beam was hooked to the LMMSA ramp module, then the LMMSA was lifted (Figure 13). Once lifted, wire rope comealongs attached to the skate assemblies were used to pull the LMMSA toward the "ELCAS". As the LMMSA was moving toward the "ELCAS", the skate assemblies started digging into the transition between two sets of dunnage. The LMMSA was lowered back onto the floating causeway deck where thin stainless steel plates were placed to cover the transition between dunnage. With the plates in place, the LMMSA was again lifted by the 140-ton crane. The wire rope comealongs pulled the LMMSA toward the "ELCAS", aligning the interface hardware. Once aligned, the 140-ton crane lowered the LMMSA, allowing the bridge beam to mate with the foundation beam (Figures 14 and 15). The ELCAS turntable ramp was placed on the deck of the land-based causeways at the end of the LMMSA. Because of the stacked causeway configuration, the only vehicles that could traverse the ELCAS RO/RO were a jeep and 5-ton truck (Figures 16 and 17). After these vehicles had gone down the LMMSA ramp and returned, the ELCAS RO/RO was prepared for disassembly. The wire rope comealongs were rigged to pull the LMMSA away from the "ELCAS", the turntable ramp was removed, and the LMMSA bridge lifting beam was shackled to the LMMSA. The 140-ton crane lifted the LMMSA free of the foundation beam and the wire rope comealongs pulled the LMMSA away from the "ELCAS". The crane then lowered the LMMSA onto the floating causeway deck.

Forty Foot Standoff Moor. To simulate the requirements of a six-point mooring system, the floating causeway was moored in the causeway launching slip forty feet from the land-based causeways (Figure 12). With this forty foot standoff the LMMSA would have to be shifted twenty feet towards the "ELCAS" to be within the lifting capabilities of the ELCAS 140-ton crane. The LMMSA was lifted from the floating causeway deck with hydraulic jacks so that dunnage could be placed longitudinally under the bridge beam end of the LMMSA. A four inch diameter pipe was placed on top of this longitudinal dunnage before the LMMSA was lowered to allow easy movement of the LMMSA over the dunnage. Dunnage under the opposite (skated) end of the LMMSA was waxed to reduce sliding friction. The LMMSA was then slid toward the "ELCAS" using a double snatch block arrangement between the LMMSA and wire rope comealongs. When the LMMSA was within reach of the ELCAS 140-ton crane, it was lifted and placed into the bridge beam with the aid of the wire rope comealongs. A LCM-8 generated waves and tried to push on the floating causeway while the ELCAS RO/RO was installed but had no effect. The ELCAS RO/RO was then retrieved.

Three-Long LMMSA Section Lift and Assembly. A fully assembled LMMSA is required on deck of the CPF for the ELCAS RO/RO concept; however, LMMSA module assembly on a floating platform would be difficult using a crane on a fixed pierhead. The ELCAS 140-ton crane does not have the capacity to lift a fully assembled LMMSA weighing approximately 70,000 pounds from the ELCAS deck onto the CPF, but it can lift half of that span. With this capability, it would be easier to assemble the LMMSA into two three-long sections on the ELCAS deck, then lower them individually to the CPF where they could be pulled together and connected. This feasibility was tested after completion of the ELCAS RO/RO installation tests. The ELCAS 140-ton crane was positioned so that there was a distance of fifty-five feet between the crane's center of lift and the center of the floating causeway (Figure 18). A three-long LMMSA section was lifted then positioned approximately two feet from the second three-long section. Both sections were set on top of waxed dunnage. Wire rope comealongs of 8,000 pound capacity were used to pull the two sections close together, and hydraulic jacks assisted in aligning the connectors. Once in place the two sections were connected.

Observations. The Phase I testing indicated that the LMMSA interface hardware design was feasible for use in the ELCAS RO/RO concept. Partial assembly of the LMMSA could be achieved on the ELCAS deck, with final assembly on the CPF by use of comealongs and hydraulic jacks. With the experience gained from Phase I testing, installation procedures were refined for Phase II.

PHASE II TEST

The purpose of the ELCAS RO/RO Phase II test was to validate the feasibility of erecting the LMMSA as a ramp between the CPF and an ELCAS. By mooring the CPF at the seaward end of the ELCAS then linking it to the ELCAS, a RO/RO capability would be established.

Phase II testing coincided with an ELCAS installation in July/August 1990 at Fort Story, Virginia (Figure 19). The PHIBCB's installed a thirteenth section to the standard twelve section ELCAS because a three section wide ELCAS pierhead was required for the ELCAS RO/RO concept. Pile guides were welded on top of the shear connectors on each outboard pierhead section (Figure 20). Four sacrificial 20" diameter pile were driven through each pile guide and served as a reaction surface to the RO/RO fenders mounted on the CPF. The LMMSA/ELCAS foundation beam was welded on top of the shear connectors of the center pierhead section (Figure 21).

The CPF was assembled in ACB-2's Desert Cove. The RO/RO fenders were installed on the two outboard floating causeway sections that would be in contact with the ELCAS. Installed in the retracted position, the fenders overhung the end of the causeway by approximately three feet. Three layers of dunnage were placed on the aft center section deck to insure a smooth surface for the LMMSA/CPF skate assemblies. The mooring lines and anchors required for the CPF moor were also set on the CPF deck to insure rapid installation once on site (Figure 22).

LMMSA Assembly. LMMSA assembly procedures refined during Phase I testing indicated that the LMMSA could be built in two sixty foot sections on the ELCAS deck. These sections could be lowered to the CPF where they could be pulled together using comealongs and assembled with the aid of hydraulic jacks. These procedures were to be followed during Phase II testing.

The CPF and ELCAS fender string were brought alongside the ELCAS. The fender string was then piled in place and the CPF tied off to it. The 140-ton crane was positioned on ELCAS Section 11 (refer to Figure 8) for the three-long LMMSA lift. The P&H Omega 65-ton crane was set up on the pierhead to handle the individual LMMSA modules. The LMMSA ramp module was offloaded from a truck on the ELCAS pierhead, where it was then opened and pinned to the ELCAS/LMMSA bridge beam. A parallel module was then offloaded, opened, then connected to the ramp module. After the second parallel module was connected, the three-long LMMSA section was prepared for the 140-ton crane lift. Lifting padeyes fabricated by ACB-2 were inserted in the reinforcement chain clutch opening between the LMMSA modules (Figure 18, Details A and B). A four part wire rope sling was then shackled to these padeyes and connected to the 140-ton crane hook. The 140-ton crane lifted the three-long section off of the ELCAS pierhead and set it on the floating CPF between the RO/RO fenders (Figure 23). An uneven weight distribution due to the weight of the bridge beam indicated the need for a wire rope sling with legs of different length. The second three-long section was assembled in a similar fashion. The ramp module was opened and braced. The skate assemblies were pinned to the module, then the parallel modules were connected. Due to wind gusts between twenty and thirty miles per hour, the three-long section lift was determined unsafe and was to be postponed until the following day. The 3-module LMMSA lift from the ELCAS to the center of the CPF, a distance of about 55 feet, was near the limit of the 140-ton crane.

With the loss of a SLWT that sank during the night and a forecast that called for deteriorating weather conditions over the next few days, ACB-2 decided to return the CPF to the protection of Desert Cove. The three-long LMMSA section on the ELCAS deck was disassembled and transported to ACB-2's Desert Cove where the modules were individually connected to the first three-long section on the CPF deck. With a fully assembled LMMSA on board, the CPF was ready to be moored at the seaward end of the ELCAS when weather permitted.

CPF Moor. The CPF moor is a critical factor in the ELCAS RO/RO system, particularly since the CPF is designed for low to moderate sea state conditions. An expedient mooring and retrieval procedure is essential to the success of the ELCAS RO/RO concept. The mooring configuration for the CPF at the seaward end of the ELCAS consisted of two outboard end lateral anchors, two breasting and two criss-cross lines from the CPF to the ELCAS, and two RO/RO fenders on the CPF bearing upon piles driven at the end of the ELCAS (Figure 24). The piles were supported laterally by two pile restraint guides welded to the ELCAS deck.

The CPF was towed from Desert Cove to the ELCAS site with the assistance of three LCM-8's, two CSP's, and one SLWT (Figure 25). Conditions for the ELCAS RO/RO installation were a slack tide, no significant sea state, and no wind. ACB-2 planned to drift the CPF into the piles at the end of ELCAS and let the RO/RO fenders bear against the piles to help hold the CPF in place while the mooring lines and anchors were set. While trying to bring the CPF toward the ELCAS, the six craft were unable to line up the RO/RO fenders with the piling due to coordination difficulties. As a result, the overhanging LMMSA ramp module struck the sacrificial piling. The criss-cross lines were passed from the ELCAS to the CPF to assist with the CPF alignment. Once the fenders and piles were aligned (Figure 26), the longitudinal mooring legs were passed from the CPF to an inflatable. The inflatable brought the lines back under the ELCAS and shackled them to wire rope that had been passed through double angles on the ELCAS. With the craft still holding the CPF against the pile at the end of the ELCAS, a SLWT lifted an aft anchor off of the CPF deck with its A-frame, and once it had backed into place, lowered the anchor to the seafloor. The second aft mooring anchor was then placed in similar fashion.

ELCAS RO/RO Installation and Retrieval. With the CPF moored at the seaward end of the ELCAS, preparations were made for the lift of the LMMSA (Figure 27). The 140-ton crane was moved to the center pierhead section and set up approximately four pontoon cans back from the seaward end. The LMMSA bridge lifting beam was secured to the crane hook and lowered to the LMMSA. After the lifting beam had been fastened to the LMMSA bridge lifting padeyes on the ramp module, the 140-ton crane lifted the LMMSA until it was just above ELCAS deck level (Figures 28 and 29). Wire rope comealongs that were attached to padeyes on the skate assemblies were then used to pull the LMMSA toward the ELCAS. Once the interface hardware was lined up the 140-ton crane lowered the LMMSA and LMMSA/ELCAS bridge beam onto the foundation beam (Figure 30). The beams were then shackled together. The mating operation was quite efficient in the calm seas; however, higher seas and consequent CPF motions are likely to make the operation more difficult.

After the LMMSA had been installed between the CPF and ELCAS, it was prepared for retrieval. After the 140-ton crane lifted the LMMSA with the bridge lifting beam, the comealongs, which had been re-rigged, pulled the LMMSA away from the ELCAS. While the crane had the LMMSA suspended, a set of long period waves from a passing ship caused the CPF to surge, sway, roll and pitch. This motion caused the LMMSA to surge and sway at the crane hook. No damage was done to the crane, so it lowered the LMMSA to the CPF deck.

The LMMSA was once again prepared for installation between the CPF and ELCAS. Because the LMMSA shifted sideways at the skate assemblies during the CPF motion, the LMMSA was moved back in place using the wire rope comealongs. Once in place, the wire rope comealongs were rigged to shift the LMMSA toward the ELCAS. The bridge lifting beam was attached to the LMMSA and the 140-ton lifted the LMMSA into position. The wire rope comealongs were used to align the interface hardware. Once aligned the crane lowered the LMMSA until the interface hardware was connected.

With the LMMSA installed between the CPF and ELCAS, the PHIBCB's prepared the ELCAS for RO/RO operations. The 140-ton crane was moved to ELCAS Section 11. A spare ELCAS beach ramp was placed on the ELCAS deck at the edge of the LMMSA with a 30-ton crane. A forklift then placed the spare turntable ramp at the end of the beach ramp. A tractor-trailer on the NL causeway section that was end connected to the CPF was then driven up and over the LMMSA (Figures 31 and 32). The tractor-trailer drove off the ELCAS, turned around, and headed back across the

ELCAS toward the LMMSA. At the pierhead it climbed the turntable and beach ramp, then traveled down the LMMSA onto the CPF deck (Figures 33 through 36). There were no interference problems for the tractor-trailer in traversing the dual ramp transition from LMMSA to the ELCAS pierhead deck.

The turntable and beach ramp were moved to allow the 140-ton crane to set back up for extraction of the LMMSA. The LMMSA was then lifted and lowered to the CPF deck as before. With the LMMSA strapped to the CPF deck, the aft mooring legs, and the criss-cross and longitudinal mooring lines were removed. The criss-cross mooring lines were difficult to release because they were shackled at both ends. The tender craft then extracted the CPF from the end of the ELCAS (Figure 37). A ten to fifteen mile per hour northerly wind with a low end sea state 2 condition prevailed for the ELCAS RO/RO disassembly.

Observations. Phase II testing indicated that erecting the LMMSA as a ramp between the CPF and an ELCAS to provide a RO/RO capability across the ELCAS was feasible. The mooring system as installed did not contain the CPF motions adequately in long period waves. The pile guide, as installed, could come in contact with the RO/RO fenders if extreme high tides are experienced.

It should be noted that because of the limited availability of tender boat support required to moor and retrieve the CPF, the ELCAS RO/RO installation, operation, and retrieval had to be completed in one day. Within this day only a limited sea state 2 was experienced, and that for only a short time.

DISCUSSION

The mooring system did not contain the motions of the CPF in long period waves. Although no adverse weather was encountered during the tests, a series of long-period waves generated by a passing ship caused the CPF to move significantly during a critical point of the LMMSA retrieval operation. There was concern that the CPF fenders might move off the barrier piles. No damage resulted as the crane operator handled the unexpected motions with savvy experience. This could create serious problems during lifts of the LMMSA in future installations. The tests point to a mooring system in which the mooring lines can be pulled taut to hold the CPF in place with limited motions. In particular the criss-cross lines could not be tightened because they were secured by shackles at both ends. The other mooring lines were secured on the CPF by mooring bitts where they could be pulled taut or could be removed quickly to break the mooring.

The pile guide, as installed, could come in contact with the RO/RO fenders if extreme high tides are experienced. Redesign of the pile guide to eliminate the overhanging angle seems necessary.

The mooring procedure should be revised. Coordination of the six craft maneuvering the CPF was too difficult to insert the CPF precisely into the moor at the end of the ELCAS. It was difficult to control the momentum of the CPF once it was moving toward the ELCAS. One suggestion to control the forward momentum of the CPF was to end connect a SLWT to the CPF and have the SLWT drop its stern anchor as the CPF approaches the ELCAS. The anchor can then control the forward movement of the CPF to prevent a hard landing. Ships use their stern anchor in maneuvers of this type. The criss-cross mooring lines are particularly important as the CPF nears the ELCAS. They are needed to hold the CPF in line with the ELCAS once the CPF fenders contact the barrier piles. For this test the criss-cross lines were 1-1/8 inch wire rope with eyes in both ends. Considerable delay was experienced in handling the lines and securing them to the ELCAS and the CPF. A hawser would have been easier to handle. For future operations the hawser should be deployed from the ELCAS, where it could be quickly tossed down to the CPF. The CPF should be fitted with appropriate fairleads and mooring bitts so that the mooring lines can be secured or removed quickly.

Level dunnage without gaps or ridges for the LMMSA footing was important to the proper functioning of the skates. The paraffin wax provided a moderate friction surface to permit movement of the LMMSA footing on the skates with light comealongs. Uneven dunnage would stop the skates. The dunnage pattern shown on Figure 22 worked well.

Lifting of the three LMMSA modules from the ELCAS to the center of the CPF was near the limit of the ELCAS 140-ton crane. It would not be advisable to attempt the lift in adverse weather. The alternate assembly of the LMMSA on the CPF is to lift one module at a time from the ELCAS onto the CPF and assemble the LMMSA using wire rope comealongs and hydraulic jacks. This process will be slower and will require a partial assembly of the LMMSA on the center CPF causeway section. The partial LMMSA, which must include the skate footing, is then pulled to its staging position with comealongs. Then the rest of the LMMSA is assembled. This complex procedure is necessary because the LMMSA cannot be assembled on two adjacent hinged causeway sections. The hinging motion would strongly inhibit connecting the LMMSA modules.

FINDINGS

LMMSA Assembly on CPF:

- Three LMMSA modules can be assembled on the ELCAS and transferred to the CPF with the 140-ton ELCAS crane; however, the lift to the center of the CPF is near the limit of the crane;
- Final assembly of the "half" LMMSA can be accomplished on the CPF using 8,000 pound comealongs, waxed dunnage, and hydraulic bottle jacks; and
- The LMMSA can be assembled on the CPF one module at a time, using comealongs, waxed dunnage, and hydraulic jacks; however, the CPF hinge joint requires assembly of 116-foot LMMSA on 90-foot causeway. Longitudinal repositioning with comealongs of LMMSA on dunnage is required to avoid joint.

CPF Mooring:

- The 40-foot standoff moor would make the LMMSA installation between the CPF and ELCAS more difficult compared to the contact moor;
- The mooring procedure tested lacked control and coordination;
- Mooring arrangement tested had no way to tension mooring lines;
- Fixed length wire rope for the criss-cross mooring could not be installed in a taut moor; and
- Long period waves increase CPF motions.

LMMSA Installation and Retrieval:

- The 140-ton ELCAS crane installed and retrieved the LMMSA in the contact moor and the simulated 40-foot stand-off moor;
- The rhino horn type interface between the ELCAS and the LMMSA provided the required degrees of freedom to accommodate ramp motions from the CPF and simplified the connection procedure;
- The 120-foot (nominal) LMMSA provided a 9 degree ramp angle; and
- The LMMSA footing with level dunnage, skates, and wax provided a functional interface.

LMMSA Operation:

- The transition from the LMMSA to the ELCAS was accomplished with a 30-foot long ELCAS beach ramp and a turntable ramp; and
- a tractor-trailer (40' flatbed) was able to mount, negotiate, and dismount the ramp with no interference problems.

CONCLUSIONS

LMMSA Assembly on CPF:

- LMMSA assembly on ELCAS, then transfer to the RRDF with the 140-ton crane is the most expedient way to assemble LMMSA from ELCAS; and
- The LMMSA can be assembled on the CPF in "halves" or one module at a time using comealongs, level dunnage, wax and jacks.

CPF Mooring:

- The 40-foot standoff moor increased the difficulty of the LMMSA deployment over the contact moor;
- The mooring procedure tested needs refinement;
- The CPF mooring should be capable of re-tensioning mooring lines;
- Fixed length wire rope for the criss-cross mooring could not be installed in a taut moor;
- The CPF is more motion responsive to long period waves; and

- The CPF mooring should be limited to low to moderate (mid SS 2) sea state conditions.

LMMSA Installation and Retrieval:

- The 140-ton ELCAS crane can install and retrieve the LMMSA in the contact moor and the 40-foot stand-off moor;
- The rhino horn LMMSA/ELCAS interface enhances the installation and operational feasibility of the ELCAS RO/RO concept; and
- The CPF must be moored securely during LMMSA transfer operations.

LMMSA Operation:

- The installation demonstrated the operational feasibility of the ELCAS RO/RO concept in low sea states.

RECOMMENDATIONS

LMMSA Assembly on CPF:

- Assemble the LMMSA in two 3-module units on the ELCAS, then transfer to CPF with 140-ton crane for connection of two units with comealongs. Alternate assembly is module-by-module assembly on CPF with comealongs.

CPF Mooring:

- Revise mooring hardware so that all mooring lines can be pulled taut onto bitts;
- Revise mooring procedure to retain positive control of CPF away from ELCAS to prevent collision with piling;
- Develop cross mooring lines that can be used during CPF mooring to achieve and maintain alignment of the CPF and ELCAS; and
- Investigate effects of long period waves on CPF/mooring.

LMMSA Installation and Retrieval:

- Develop a secure CPF mooring system to supplement the demonstrated LMMSA installation and retrieval operations.

LMMSA Operation:

- The ELCAS RO/RO operation with the CPF can be used in low sea states with short period waves. Further testing of the effects of long period waves is required; and
- Assess arrangement of LMMSA interface with ELCAS and location of turntable to optimize ELCAS and RO/RO operations.

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5. "Design of the Mooring System for the Causeway Platform Facility (CPF) at the End of the Elevated Causeway (ELCAS), Final Report", Giannotti & Associates of Texas, Inc., Contract N00123-88-D-0406/0007, March 16, 1990.

FIGURES

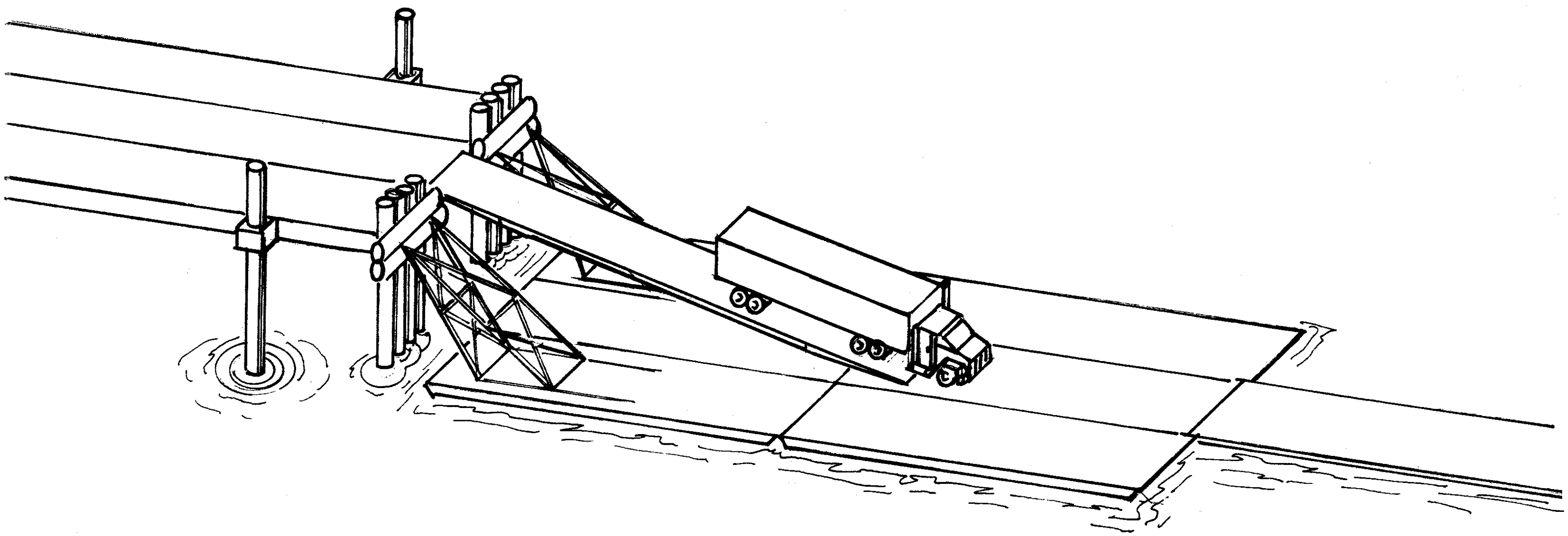


Figure 1. ELCAS RO/RO

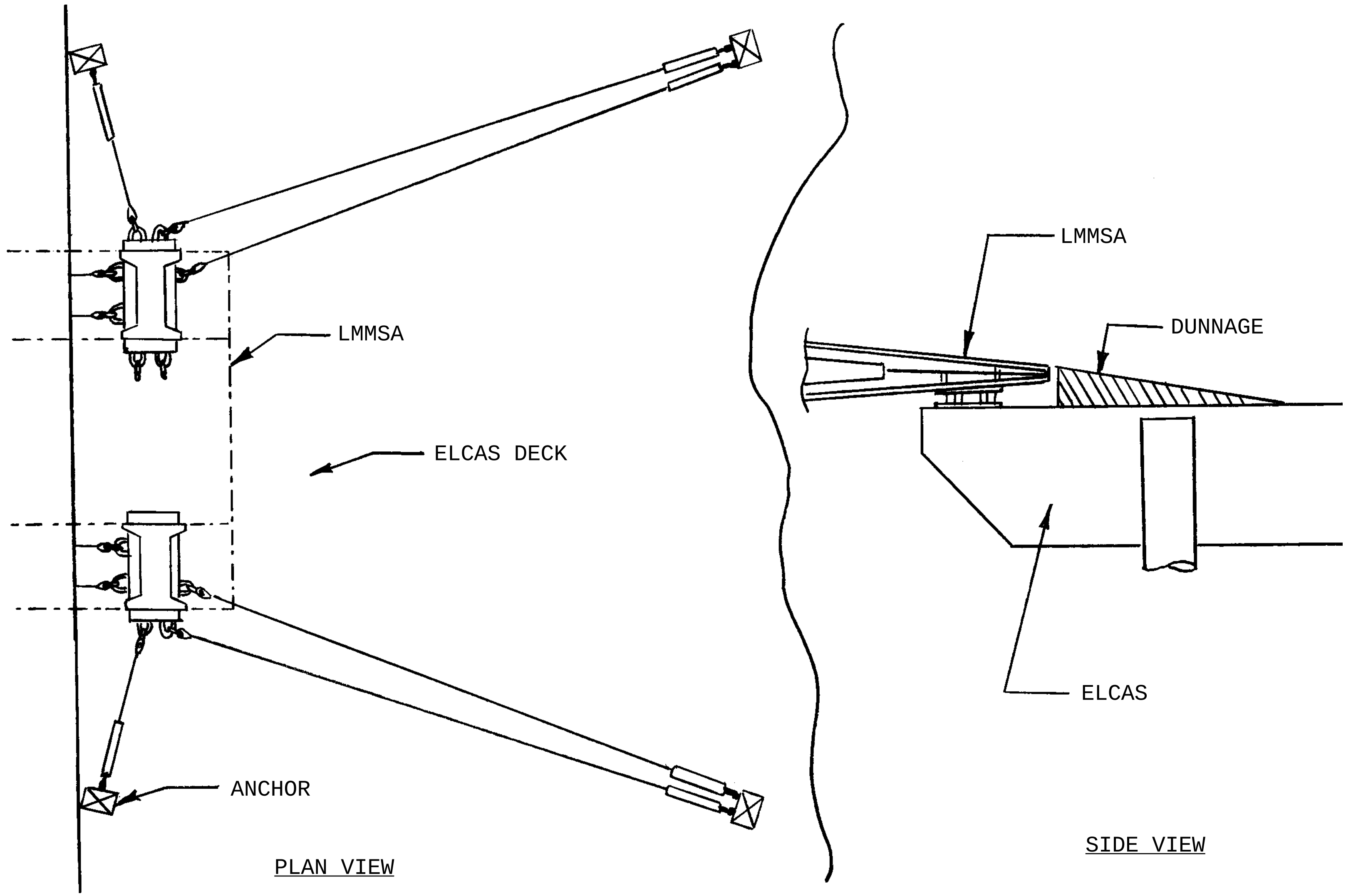


Figure 2. Upper Bearing Assembly

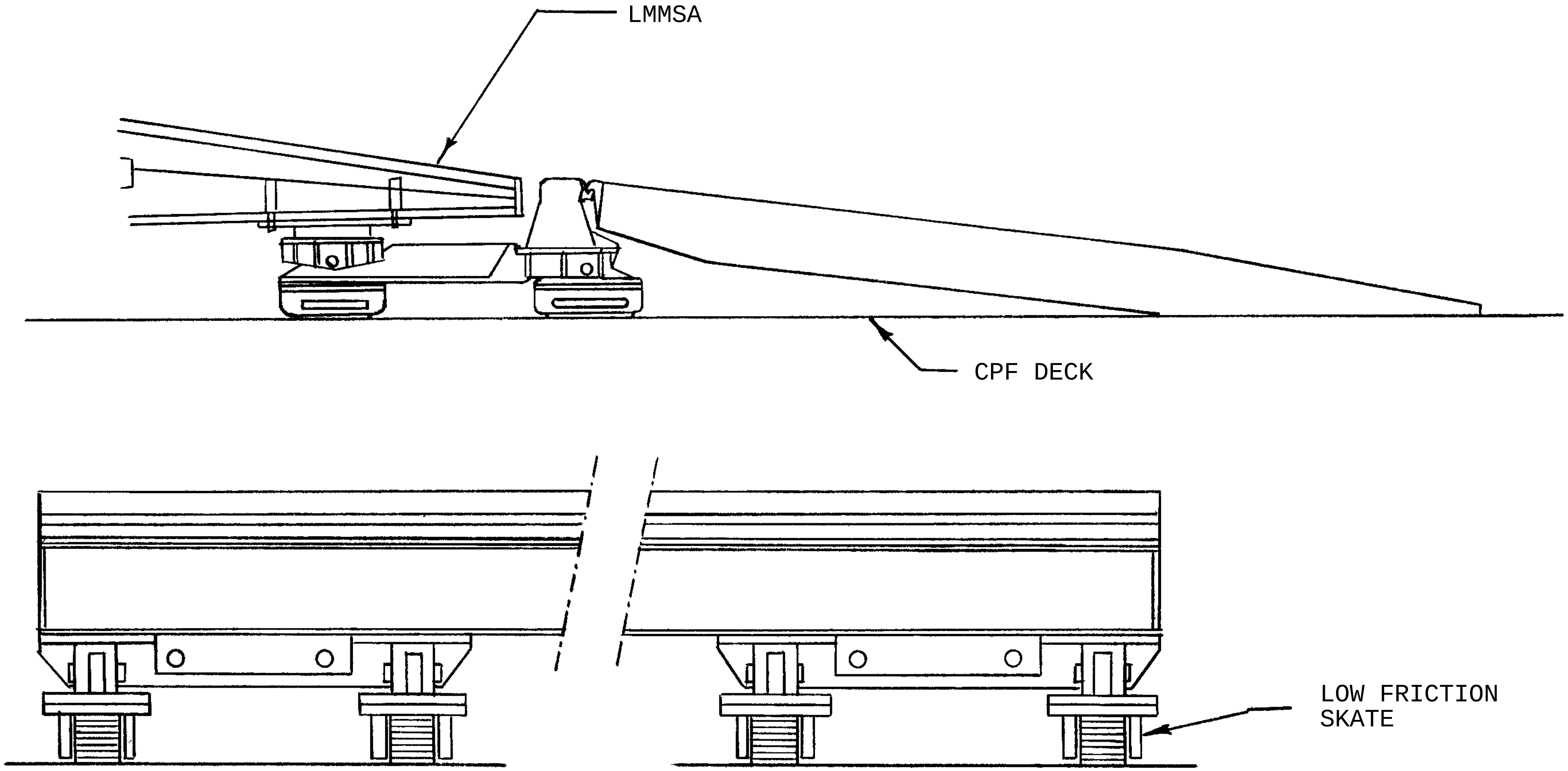


Figure 3. Low Friction Skate Assembly

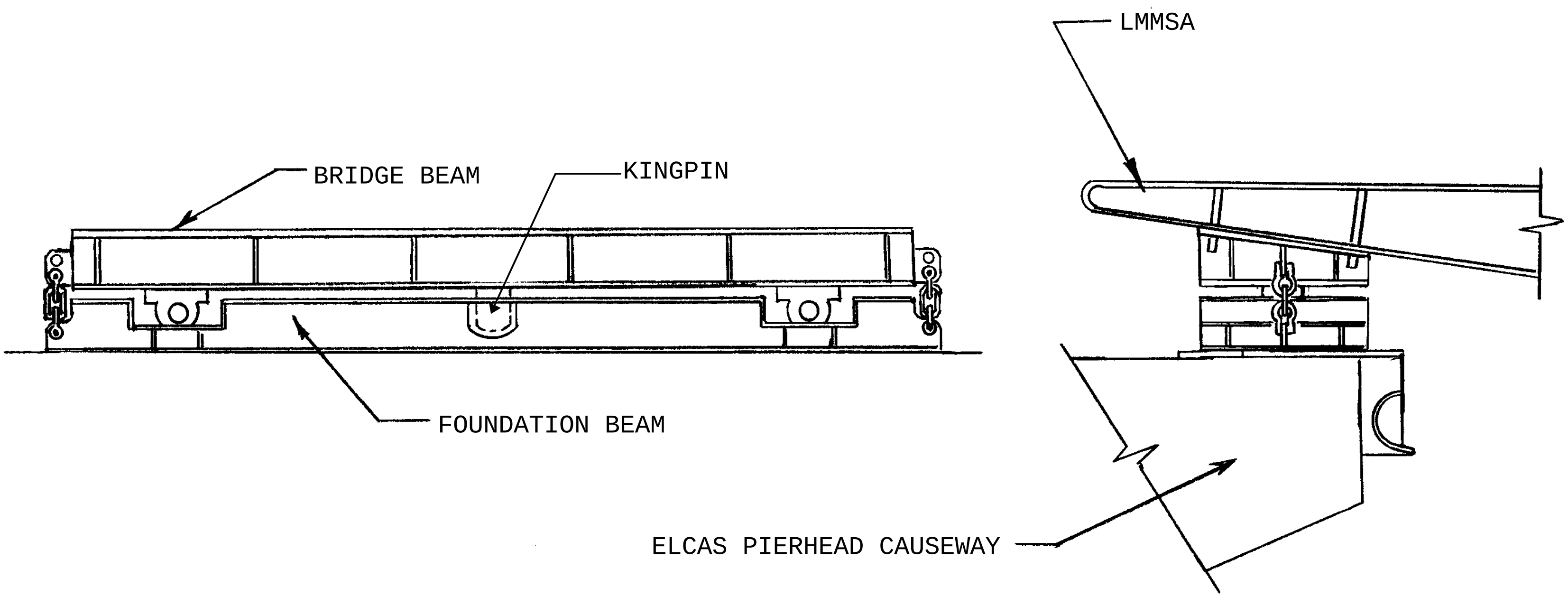


Figure 4. LMMSA/ELCAS Interface

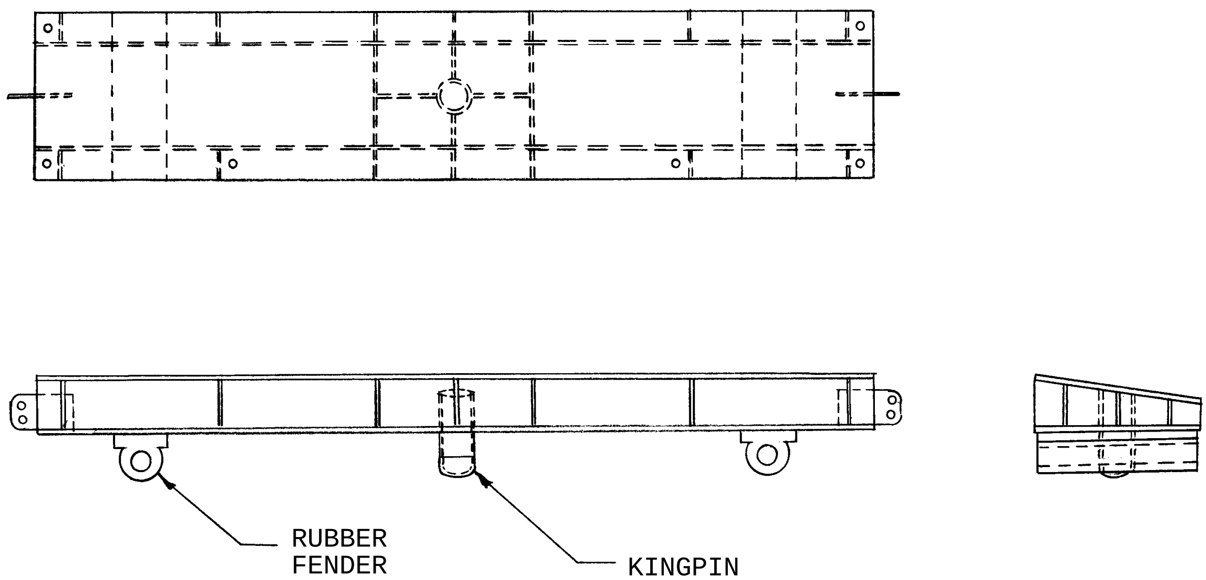


Figure 5. Bridge Beam

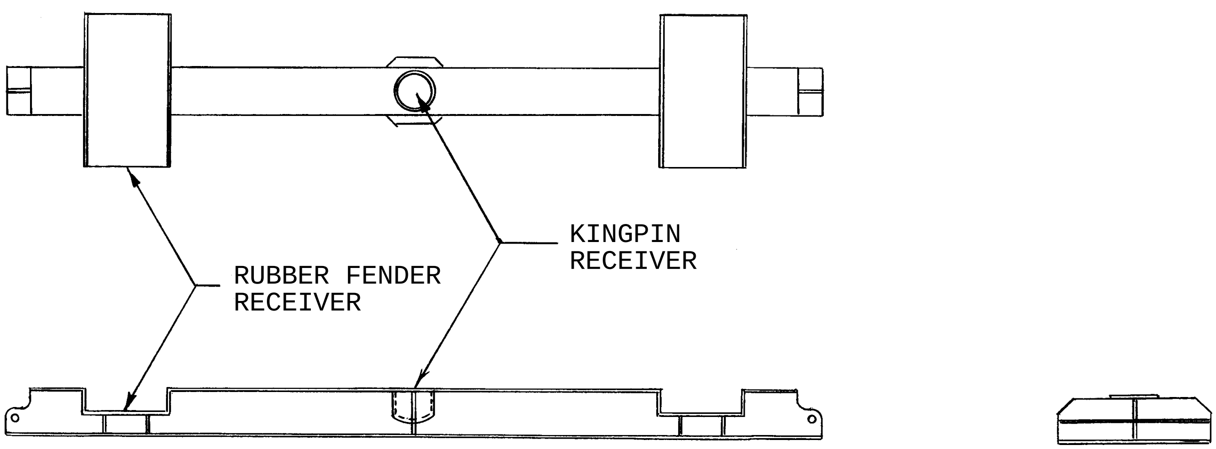


Figure 6. Foundation Beam

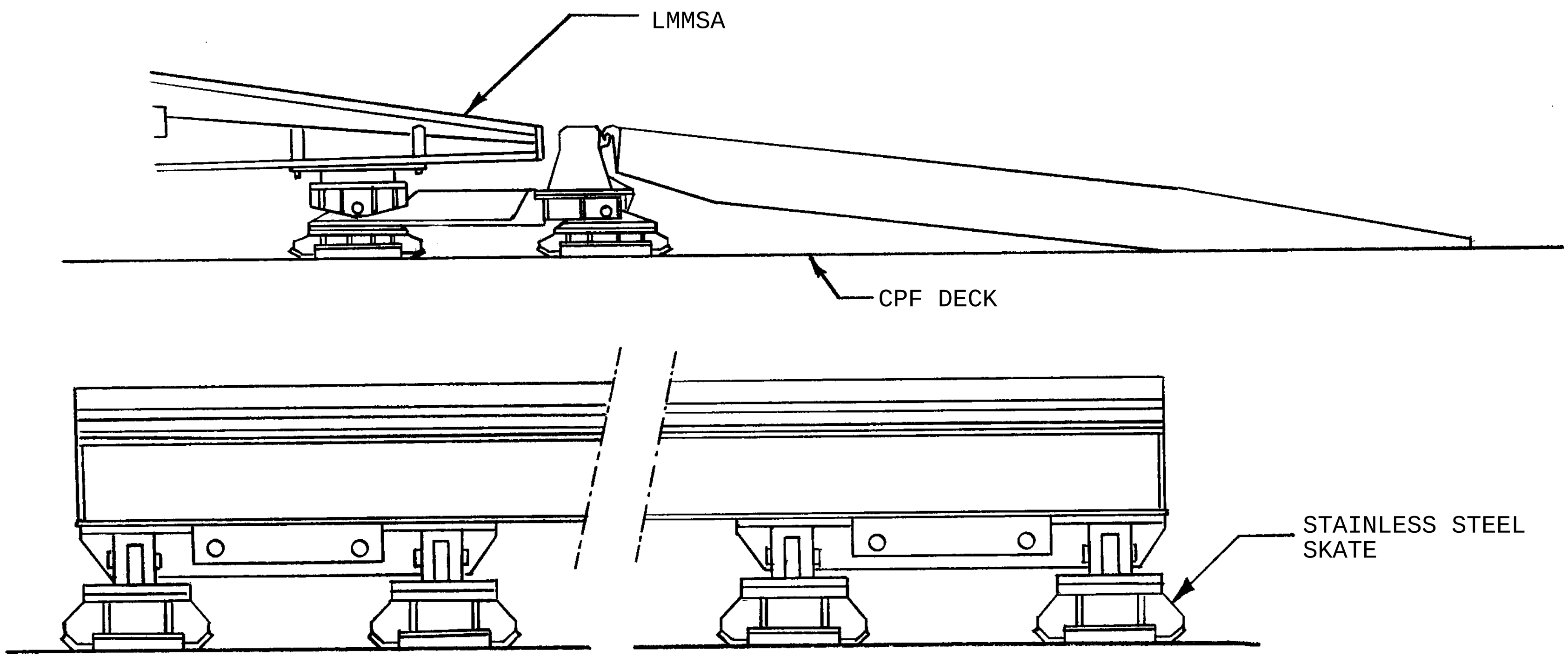


Figure 7. LMMSA/CPF Interface

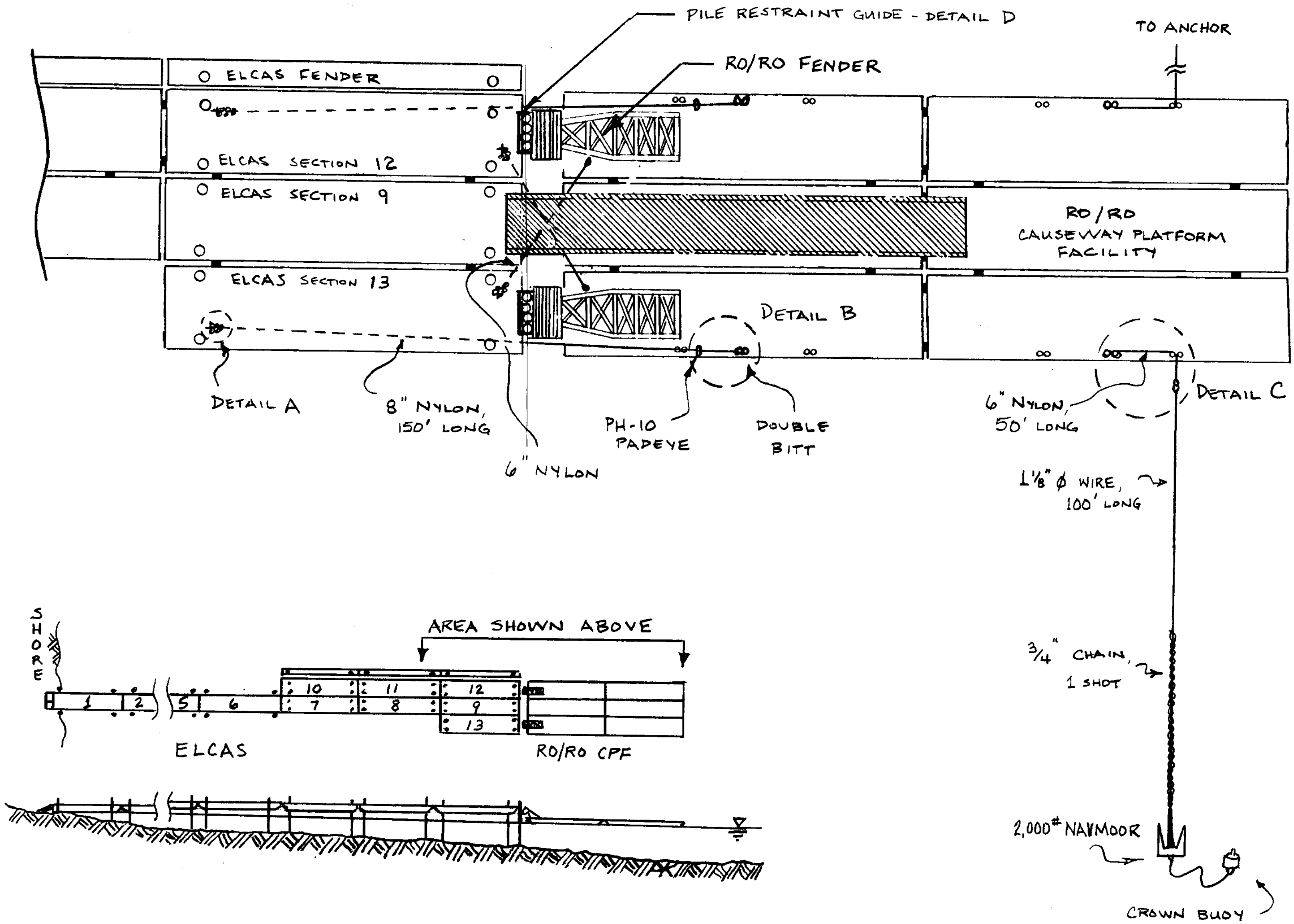


Figure 8. Mooring Arrangement - CPF to ELCAS

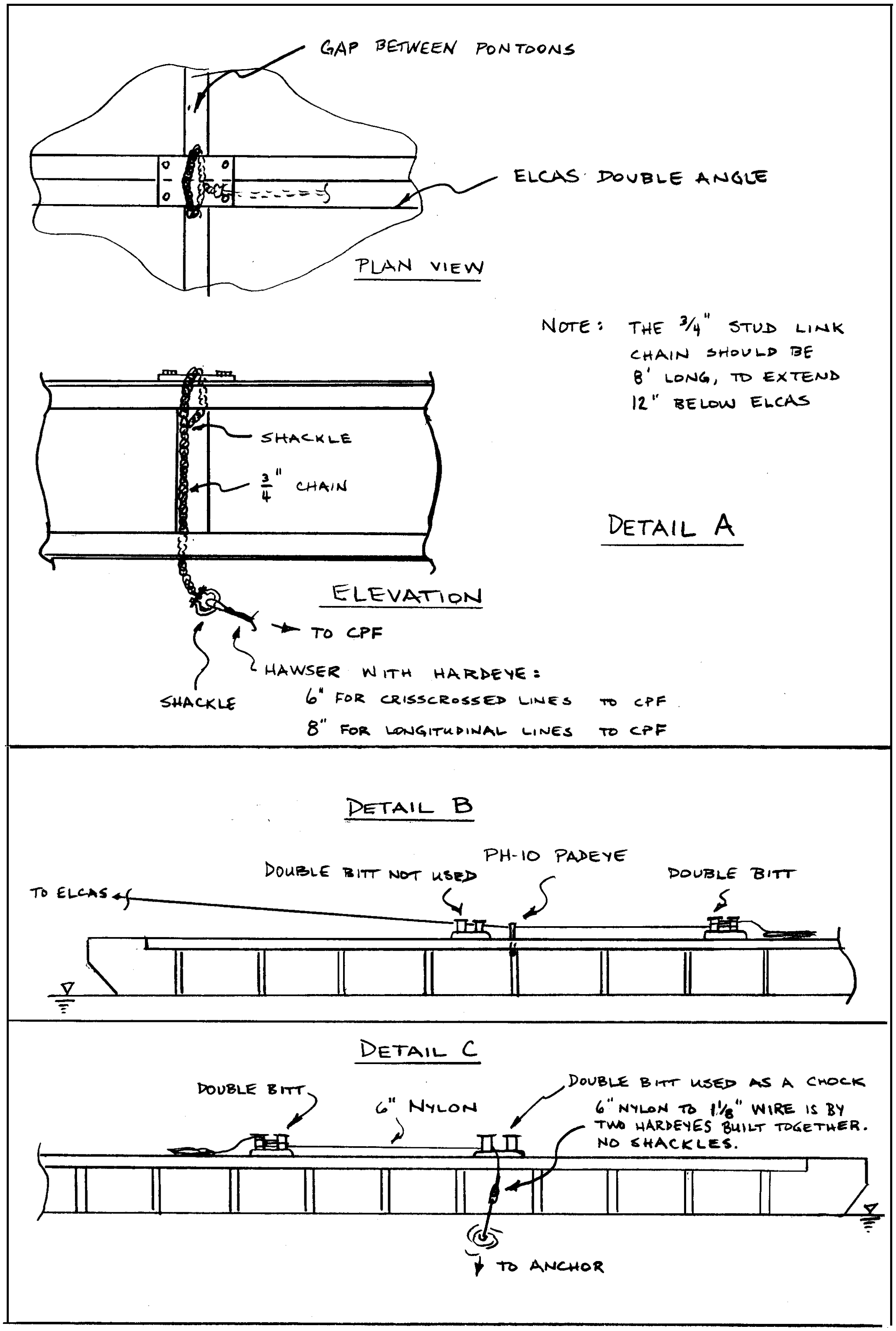
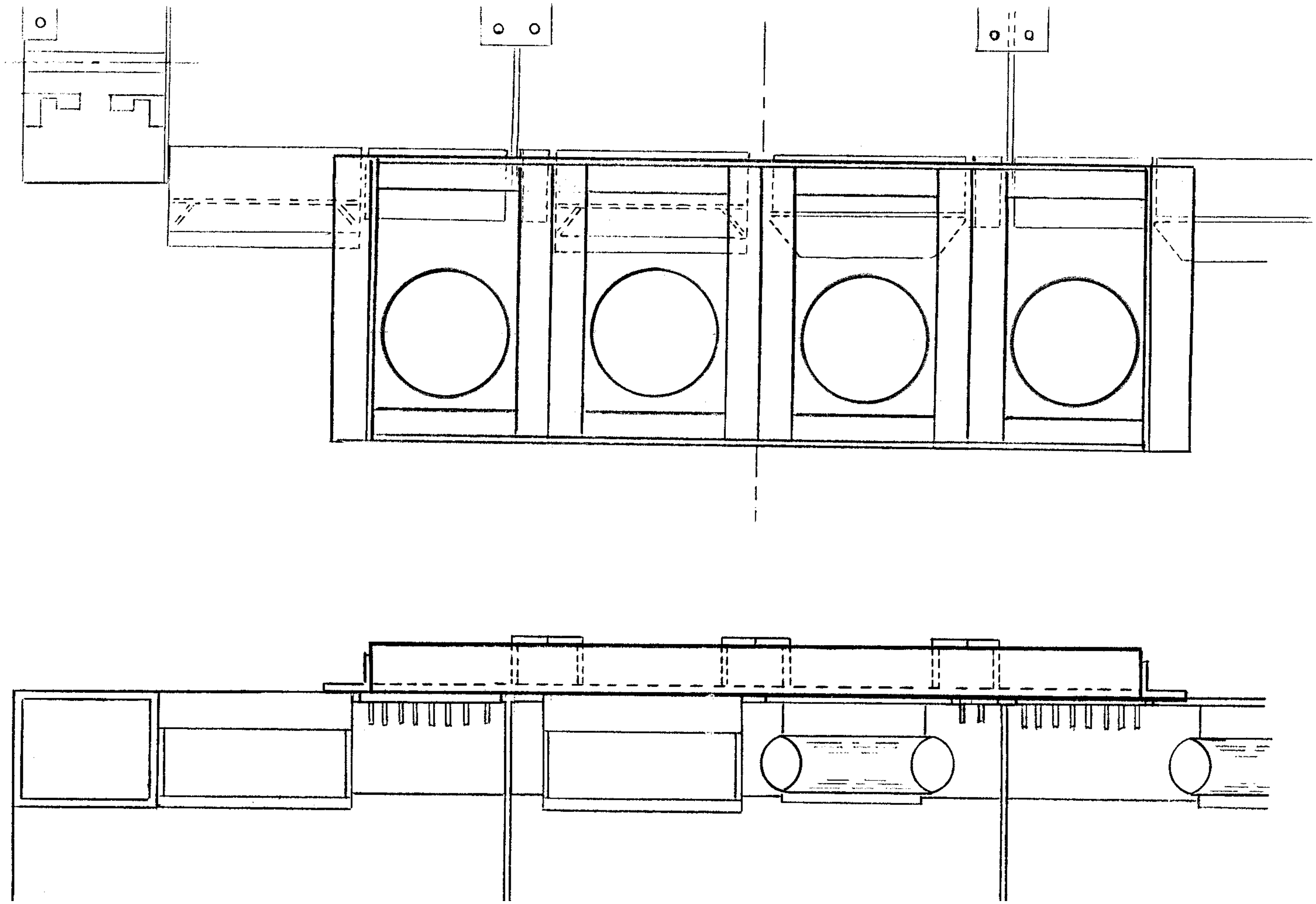


Figure 8. Mooring Arrangement - CPF to ELCAS (Con't)



Detail D - Pile Restraint Guide

Figure 8. Mooring Arrangement - CPF to ELCAS (Con’t)

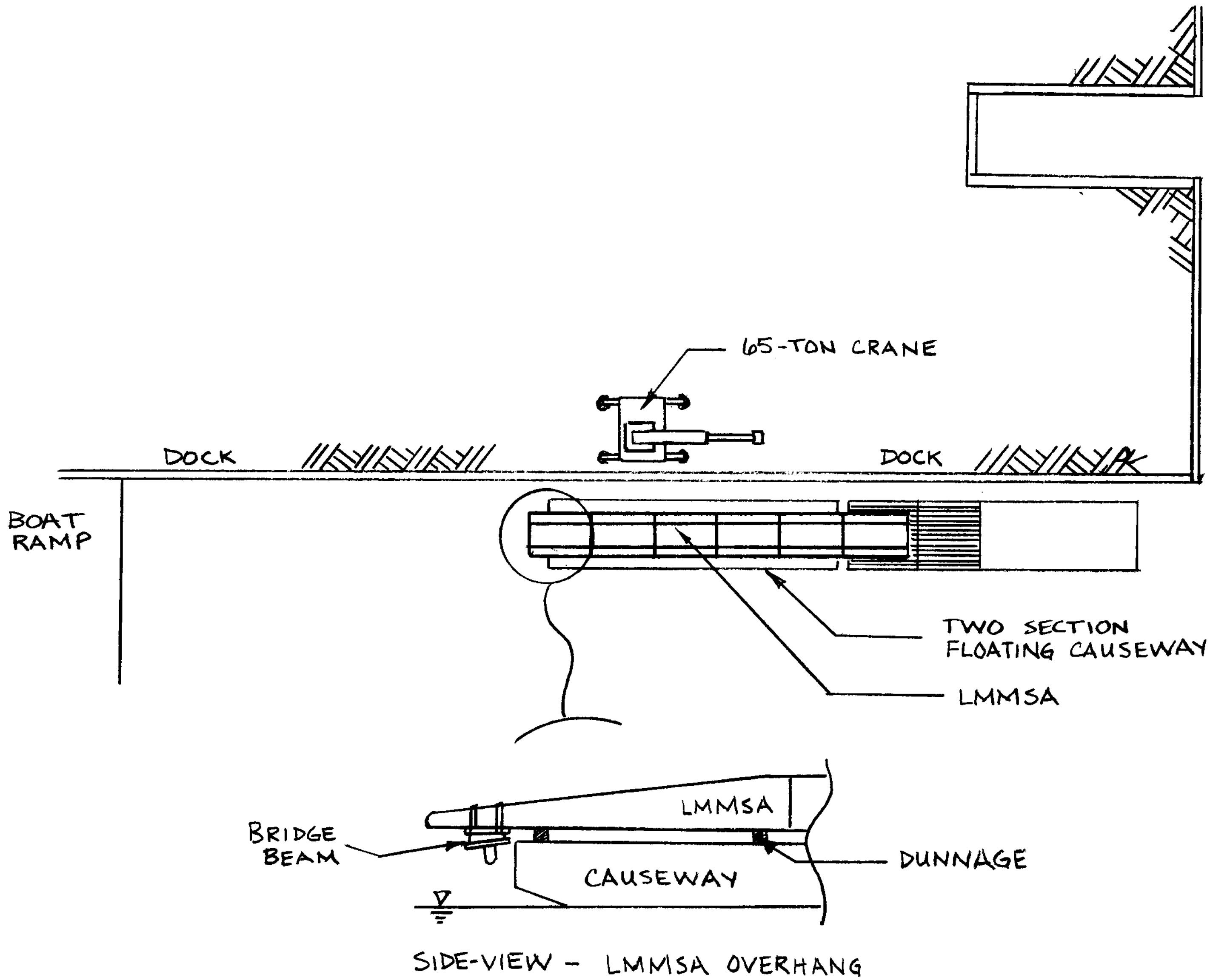


Figure 9. LMMSA Assembly at Dock

Figure 10. LMMSA Ramp Module with Bridge Beam on Floating Causeway (NCEL Photo 1700-90)

Figure 11. LMMSA Ramp Module and Skate Assemblies on Floating Causeway (NCEL Photo 1705-90)

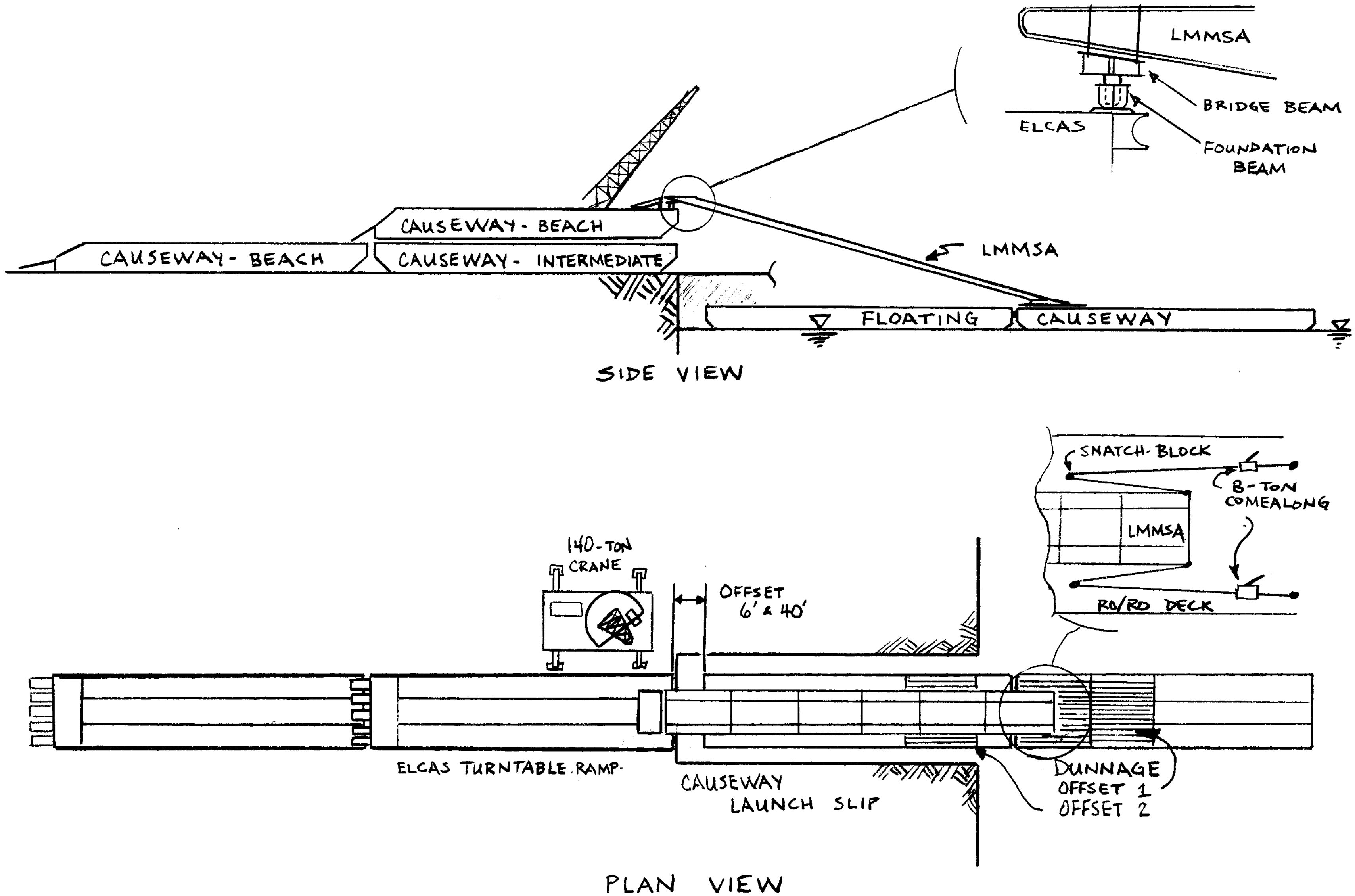


Figure 12. Phase I Test Setup

Figure 13. LMMSA Lift (NCEL Photo 1717-90)

Figure 14. LMMSA/ELCAS Interface Hardware Alignment (NCEL Photo 1727-90)

Figure 15. Installed LMMSA/ELCAS Interface Hardware (NCEL Photo 1729-90)

Figure 16. Jeep Traversing ELCAS RO/RO (NCEL Photo 1730-90)

Figure 17. Five-Ton Truck Traversing ELCAS RO/RO (NCEL Photo 1735-90)

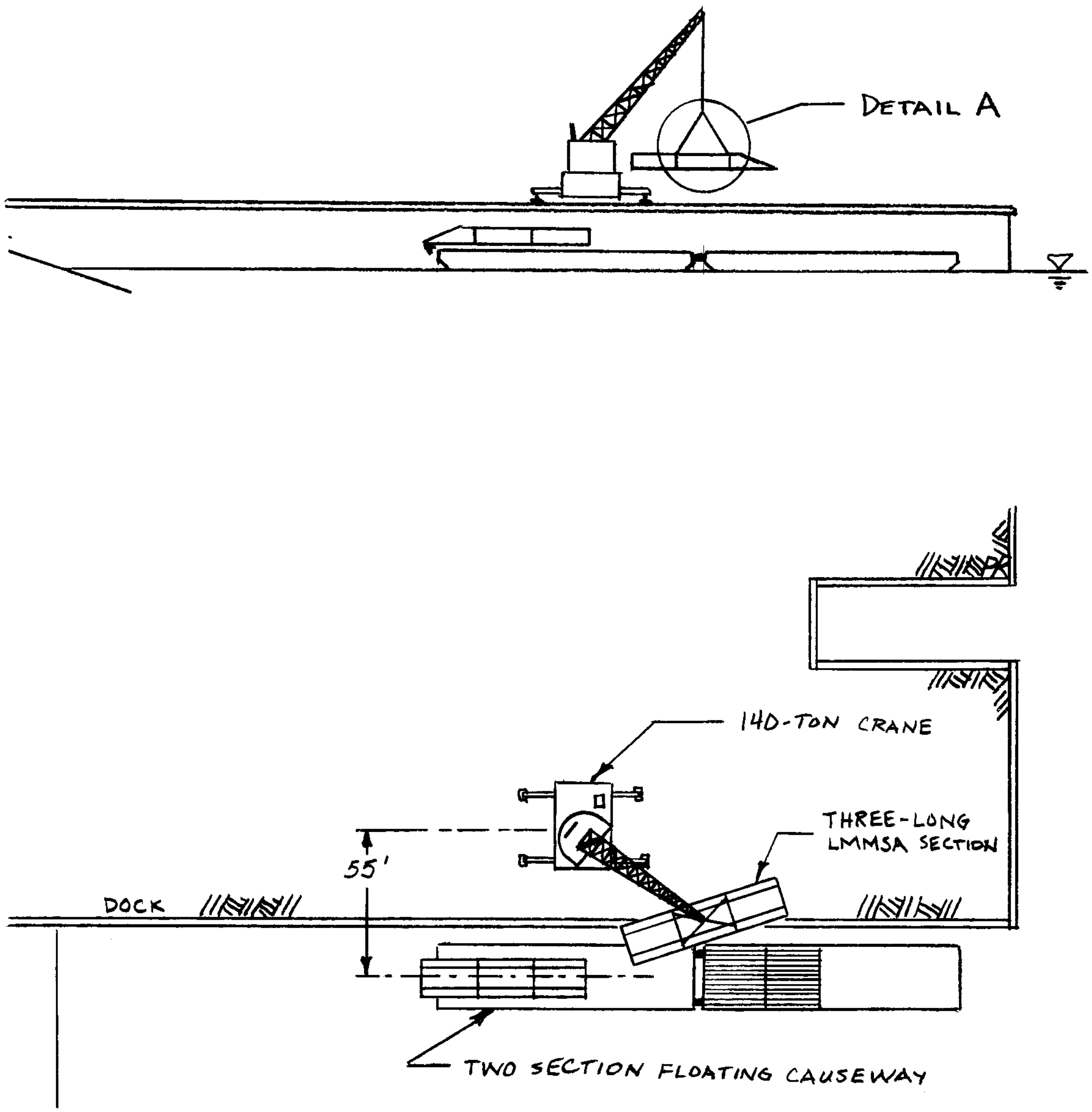


Figure 18. Three-Long LMMSA Section Lift from Dock

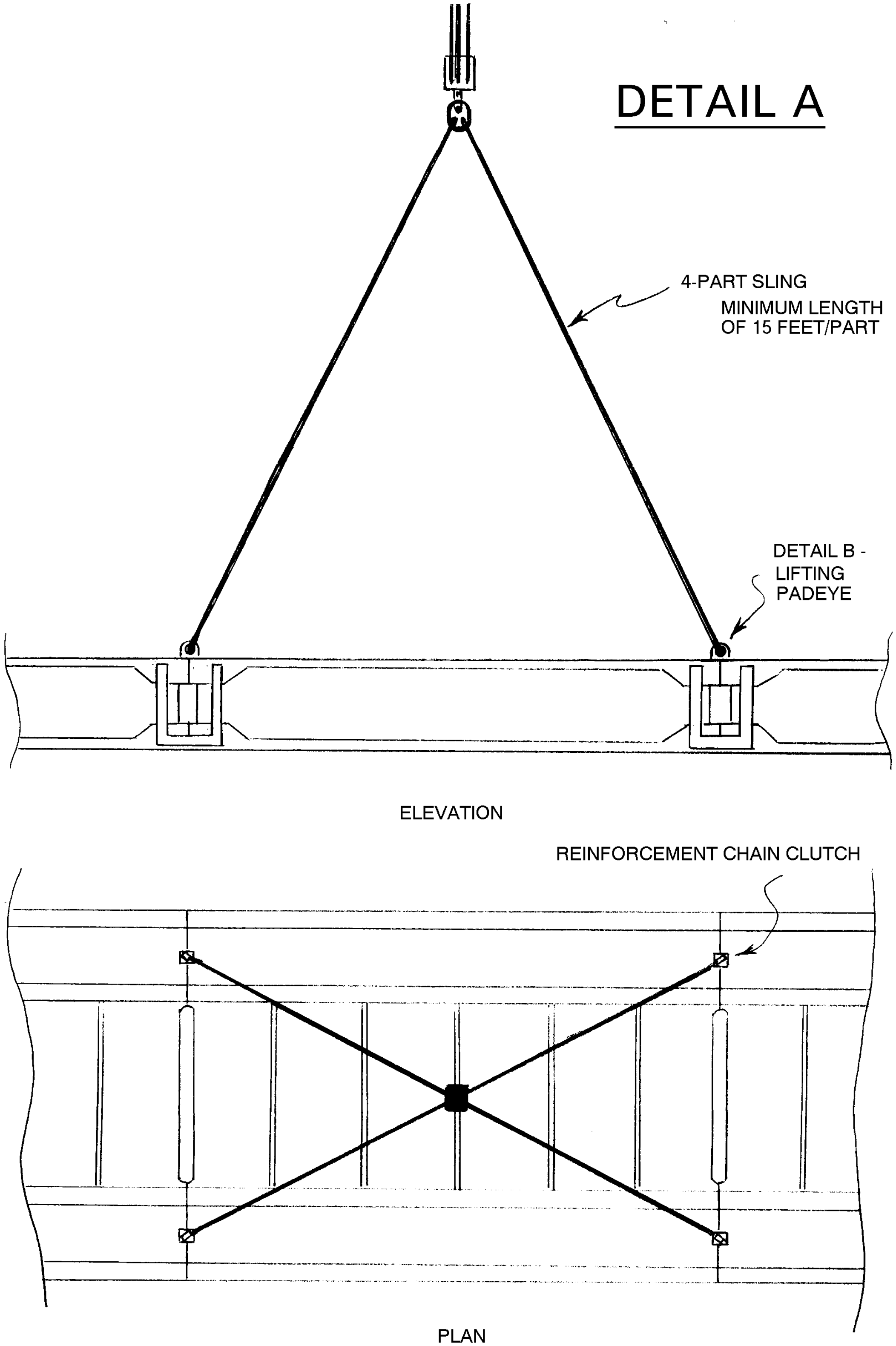
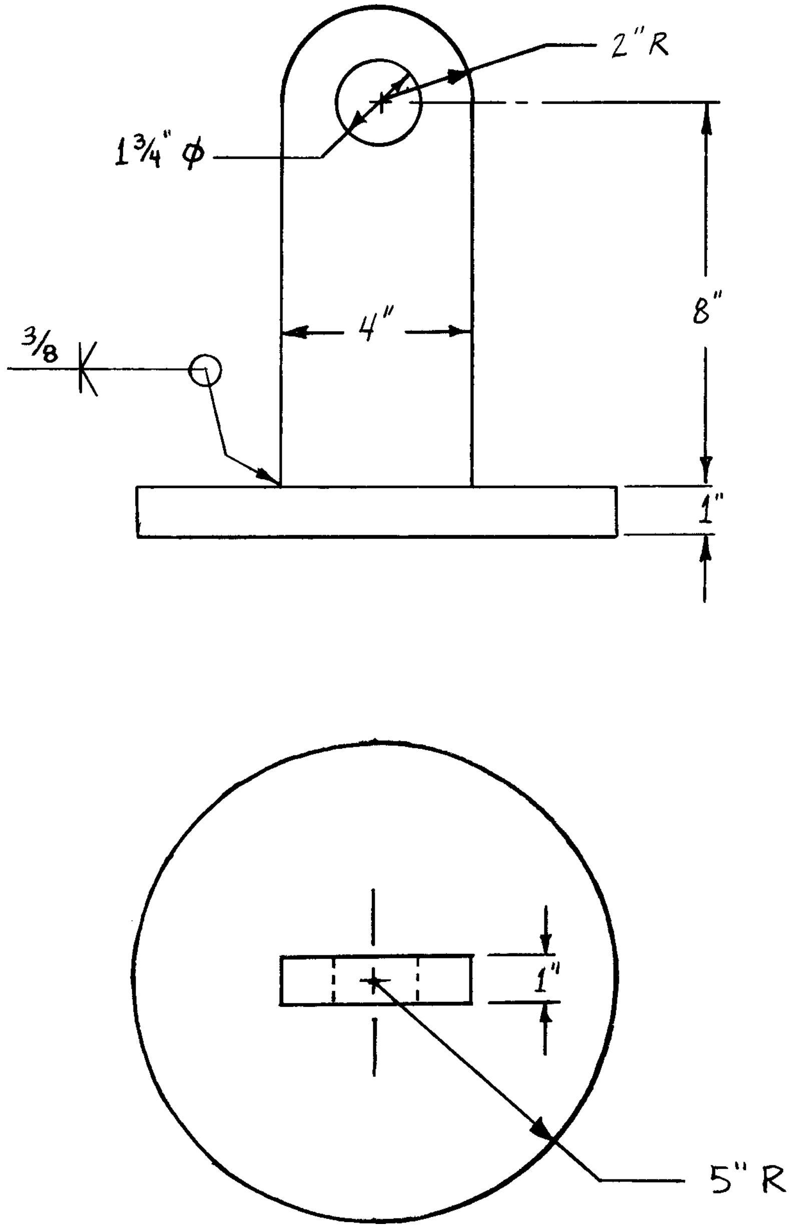


Figure 18. Three-Long LMMSA Section Lift from Dock (Con't)



Detail B - Lifting Padeye

Figure 18. Three-Long LMMSA Section Lift from Dock (Con't)

Figure 19. ELCAS Installation (NCEL Photo 2434-90)

Figure 20. Pile Guide on ELCAS (NCEL Photo 2420-90)

Figure 21. LMMSA/ELCAS Foundation Beam on ELCAS (NCEL Photo 2428-90)

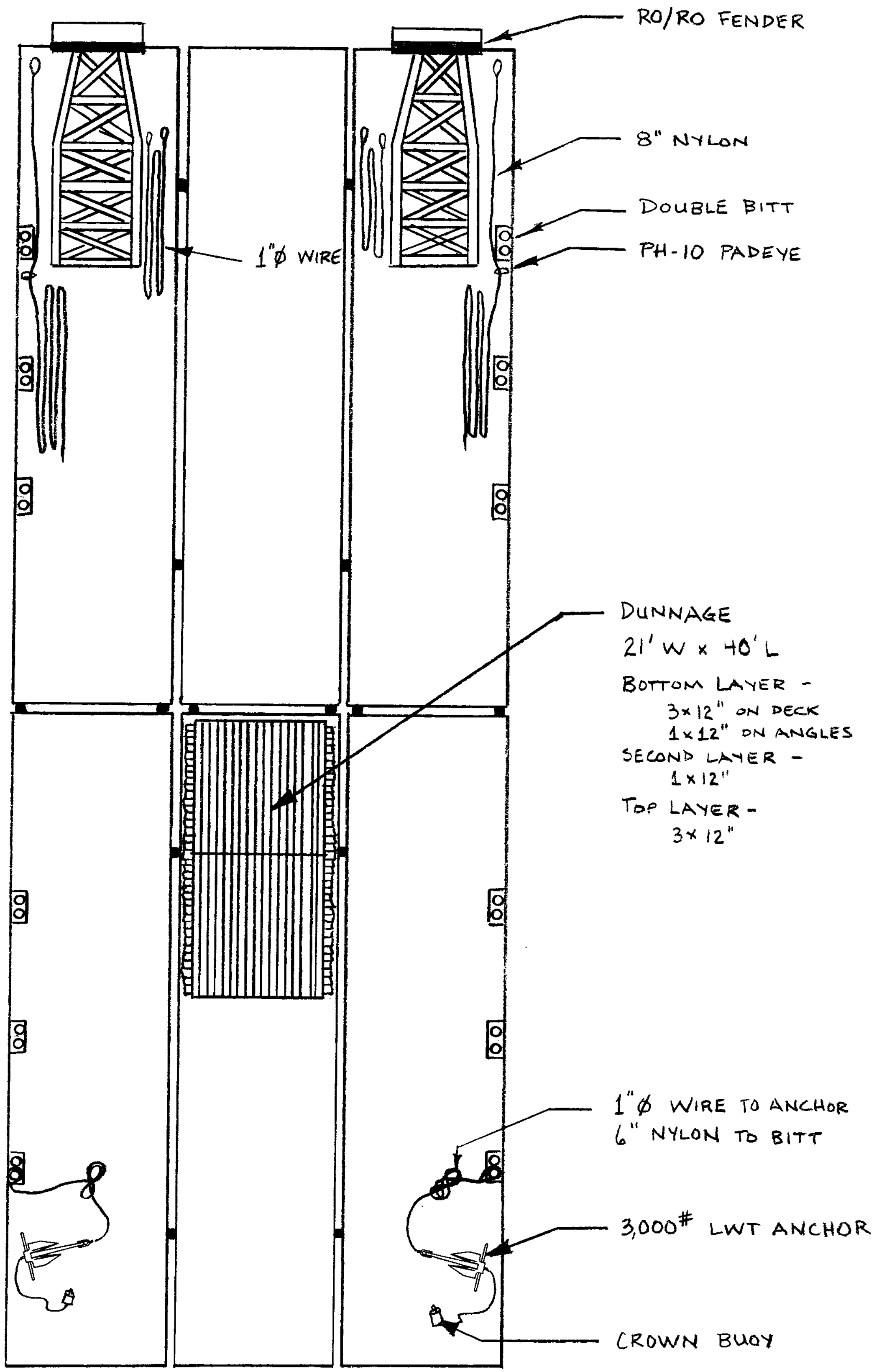


Figure 22. CPF Deck Layout

Figure 23. Three-Long LMMSA Section Lift from ELCAS (NCEL Photo 2409-90)

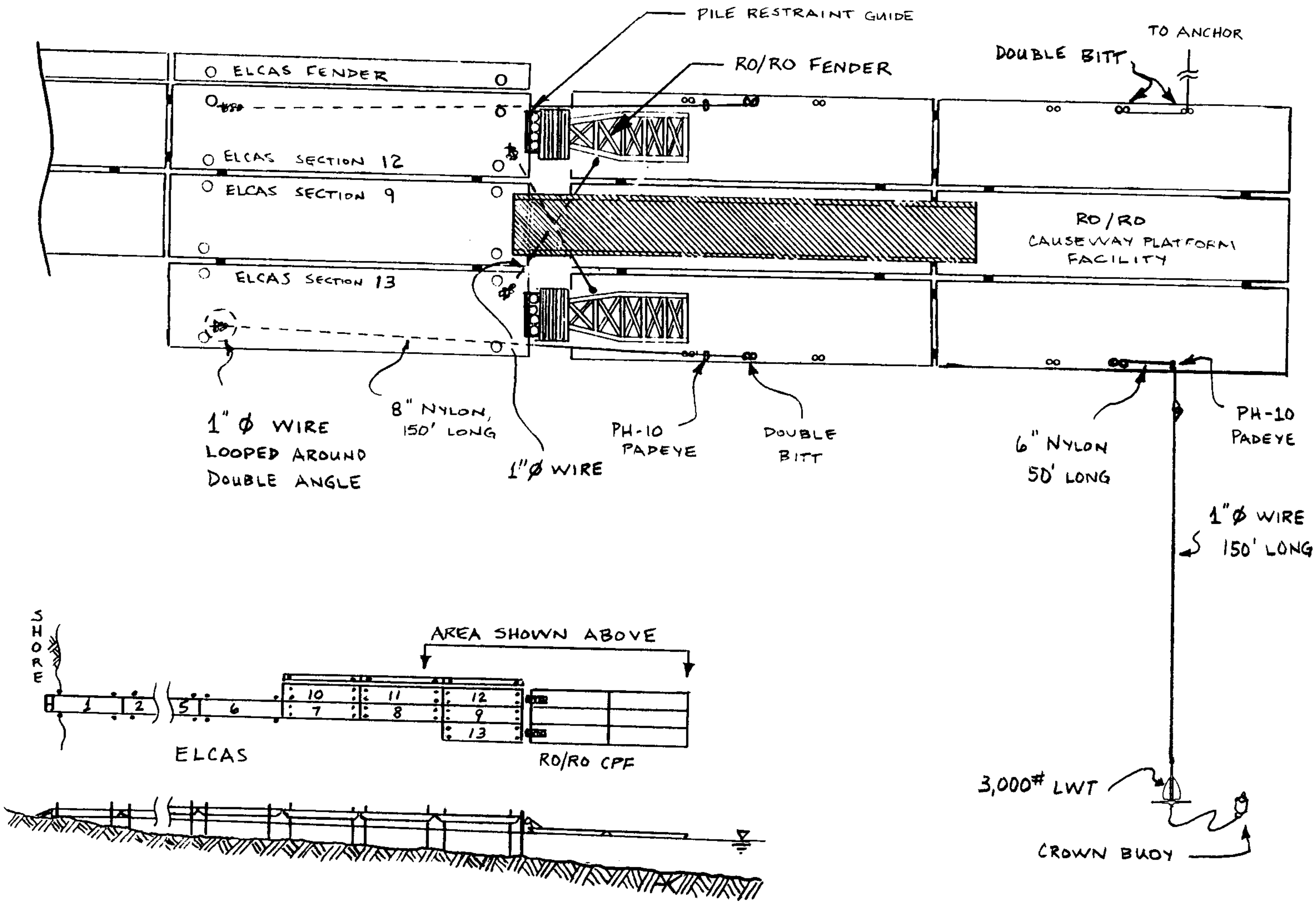


Figure 24. Mooring Arrangement - CPF to ELCAS, as Installed

Figure 25. CPF Approaching ELCAS (NCEL Photo 2489-90)

Figure 26. RO/RO Fender and Sacrificial Pile Alignment (NCEL Photo 2477-90)

Figure 27. CPF Installed at Seaward End of ELCAS (NCEL Photo 2481-90)

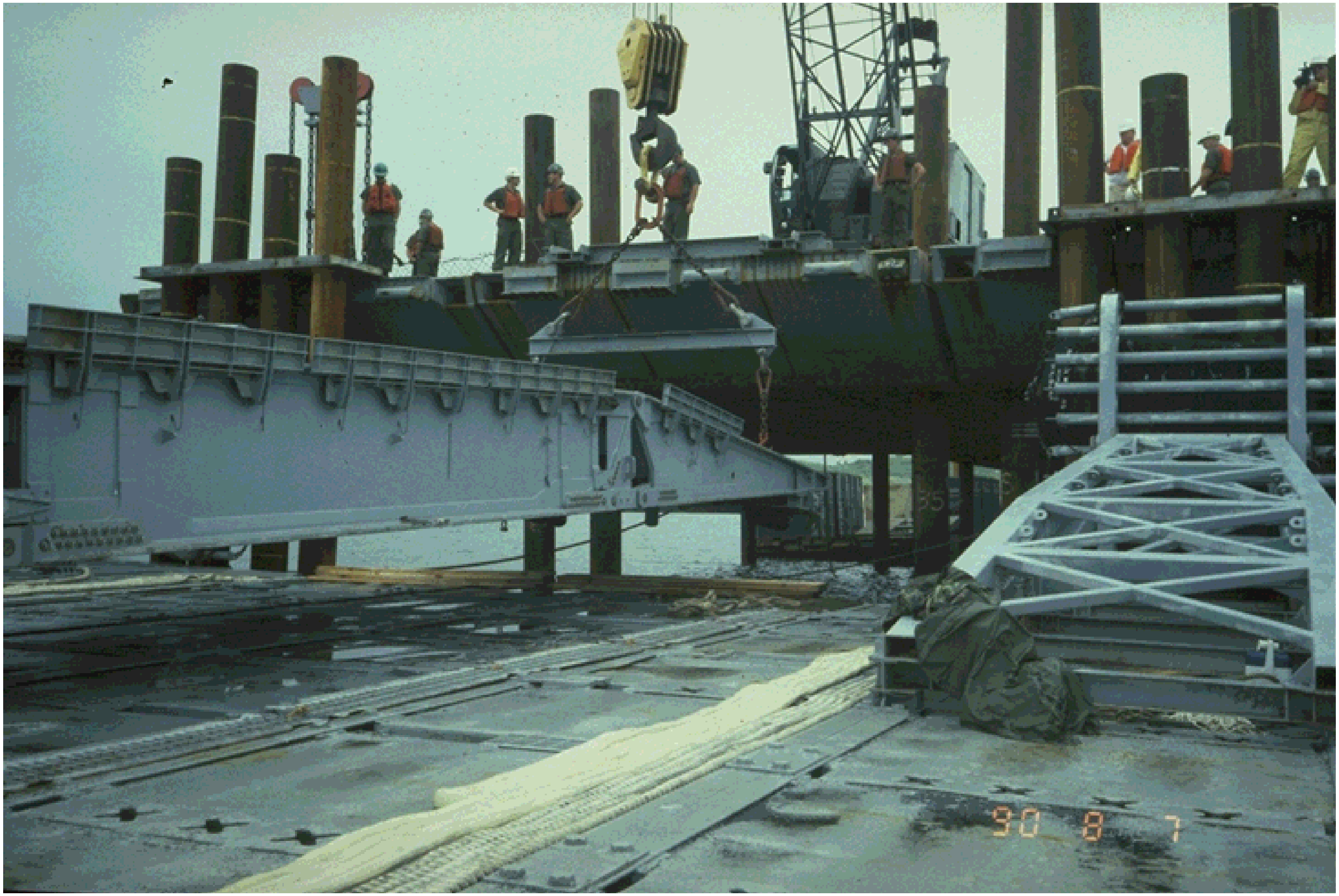


Figure 28. LMMSA Lift by ELCAS 140-ton Crane (NCEL Photo 2456-90)

Figure 29. Alignment of LMMSA/ELCAS Interface Hardware, Phase II Testing (NCEL Photo 2457-90)

Figure 30. LMMSA Installed as Ramp between CPF and ELCAS (NCEL Photo 2395-90)

Figure 31. Tractor-Trailer Approaching LMMSA Ramp (NCEL Photo 2403-90)

Figure 32. Tractor-Trailer Crossing LMMSA/ELCAS Interface (NCEL Photo 2475-90)

Figure 33. Tractor-Trailer Approaching LMMSA/ELCAS Interface (NCEL Photo 2474-90)

Figure 34. Tractor-Trailer Crossing Turntable and Beach Ramps (NCEL Photo 2471-90)

Figure 35. Tractor-Trailer Descending LMMSA Ramp (NCEL Photo 2469-90)

Figure 36. Tractor-Trailer Crossing LMMSA/CPF Interface (NCEL Photo 2466-90)

Figure 37. CPF Departing ELCAS (NCEL Photo 2464-90)

APPENDICES

APPENDIX A

LIST OF ACRONYMS

ACB	Amphibious Construction Battalion
CPF	Causeway Platform Facility
CSP	Causeway Section, Powered
ELCAS	Elevated Causeway Facility
LCM	Landing Craft, Mechanized
LMMSA	Lightweight Multipurpose Modular Spanning Assembly
LST	Tank Landing Ship
NAVFAC	Naval Facilities Engineering Command
NCEL	Naval Civil Engineering Laboratory
NL	Navy Lighter
PHIBCB	Amphibious Construction Battalion
RO/RO	Roll-on/Roll-off
RRDF	Roll-On/Roll-Off Discharge Facility
SLWT	Side-Loadable Warping Tug
SS	Sea State

APPENDIX B

PHASE I TEST NOTES

MON 14 MAY 90

0730	Two floating causeway sections end connected
0850	LMMSA ramp section offloaded from shipping container with P&H Omega 65-ton crane.
0900	LMMSA/ELCAS bridge beam situated for connection to ramp module. It is noted that the inside holes for two of the pins are drilled in the wrong spot. Have design drawing changed.
0920	Bracing beam attached to ramp module.
0935	Bridge beam pinned to LMMSA ramp module using two of the three pins on each side. Bridge beam and ramp sat flat on ground. Easy connection, good fit.
0945	LMMSA ramp module lowered to causeway using 4-leg sling. Module lifting beam would not work. Still had uneven lift. Need slings with different size legs.
0955	LMMSA ramp module set on causeway section with approximately a three foot overhang.
1005	First parallel module set on causeway.
1013	First parallel module connected to ramp module using 65-ton crane.
1017	Second parallel module unloaded from shipping container.
1021	Second parallel module opened.
1028	Second parallel module connected to first parallel module. Crane repositioned.
1045	Third parallel module unloaded.
1048	Third parallel module opened.
1100	Third parallel module not able to connect. High tension link tweaked? Break for lunch.
1215	Third parallel module repositioned. Top end pinned first then bottom pinned. PHIBCB's were assembling with opposite procedure. High tension link not tweaked.
1235	Third parallel module connected.
1240	Fourth parallel module unloaded.
1244	Fourth parallel module opened.
1248	Fourth parallel module lowered to causeway.
1255	Fourth parallel module connected.
1305	Ramp module unloaded.
1309	Bracing frame unloaded.
1313	Ramp module opened.
1320	Ramp module reinforced with bracing beam. Finger ramps and bottom skids delivered to site.
1325	Ramp module lowered to causeway.
1330	LMMSA/CPF skate assemblies lowered to causeway.
1350	LMMSA/CPF skate assemblies pinned to ramp module; however, not enough locking pins - break to get some.

1507	Ramp module attached to fourth parallel module. Again had problem connecting modules because modules are not level due to uneven weight distribution of skate assembly when lifted with equal length sling legs. Comealongs should be used to adjust vertical height of the ramp to make it level.

TUE 15 MAY 90

0720	Land-based causeways set in place at end of causeway launching slip. Floating causeway moved to causeway launching slip. Dunnage on floating causeway waxed with bowling alley wax. Wire rope comealongs for moving LMMSA footing rigged Turntable ramp set on deck of land based causeways for later use.
0730	140-ton ELCAS crane positioned alongside 2 high causeways.
0750	Applying bowling alley wax to dunnage to reduce friction.
0755	Rigging bridge lifting beam.
0810	Turntable ramp on "ELCAS" for transition from LMMSA.
0835	Snatch blocks and wire rope comealongs rigged for skidding LMMSA skate footing.
0920	Begin LMMSA lift.
0930	LMMSA lifted with 140-ton ELCAS crane which was located on side of land-based causeways. Bridge lifting beam used.
0935	LMMSA lowered before fully deployed. 10' board length on dunnage left a transition that skates hung up on. LMMSA would not move forward. Stainless steel plates brought in to cover transition. Importance of compact, level dunnage emphasized.
1010	Stainless steel plates set in place under skate assemblies. Begin pulling LMMSA footing with comealongs.
1030	LMMSA lift completed and pinned in place.
1100	Jeep driven over ramp.
1102	Jeep arrived at bottom of LMMSA ramp.
1104	Jeep turned around on floating causeway deck.
1105	Jeep up and over top of LMMSA. Second jeep trip made down and up ramp. 5-ton truck down and up ramp. Break for lunch.
1245	LMMSA set up for retrieval. Wire rope released from snatch block so comealongs would have direct pull.
1256	LMMSA set on floating causeway deck after being lifted by crane and hoisted back with comealongs. Retrieval operation was quick.

WED 16 MAY 90

0730	Reposition dunnage for 40' offset
0830	Dunnage ready. Floating causeway repositioned for 40' offset in causeway slip. LMMSA lifted using hydraulic jacks to place longitudinal dunnage & set on 4" diameter schedule 40 pipe. Pipe partially collapsed under weight of LMMSA.

0855 LMMSA ready to move on 4" pipe and skids. Wire rope comealongs set up with double snatch block configuration. A 3-ton snatch block failed during hoist. LMMSA skid approximately 20' using roller pipe, waxed skates, and comealongs. LMMSA lifted into position and moved approximately 10' toward "ELCAS" using comealongs and allowing floating causeways to move in slightly. LCM-8 used to generate waves. LMMSA flexed through ramp and not at interface hardware. LCM-8 rammed causeway to move causeway under ramp footing. Did not work. LMMSA ramp makes a good anchor. LMMSA retrieved.

THU 17 MAY 90

Disassembly of LMMSA on floating causeway deck

0800 4-leg single point lift slings set up for 3-module long LMMSA lift. Used square openings between modules as lift points for LMMSA. Unable to release shoot bolts due to lack of fine control of lift with 140-ton crane. Tension link pins removed before shootbolts withdrawn. Broke tips off two of the alignment dowels that receive shoot bolts due to weight of 3 modules hanging from shootbolts.

0950 The 140-ton crane was set with a 55' offset from its center of lift to the center of the floating causeway section. The 140-ton crane lifted the 3-long LMMSA section and set it approximately two feet from the second 3-long section. Wire rope comealongs were rigged to pull the two 3-long LMMSA sections together.

0940 PHIBCB's pulled the sections back apart by rerigging the comealongs. Used two 4-ton comealongs to pull 3-module unit on waxed dunnage. Four bottle jacks were used to jack connection interface into alignment.

0950 Two 3-long sections pulled back together. Very little friction. One side got ahead of the other and would not align.

0955 Hydraulic jacks (8- and 5-ton each side) set up underneath LMMSA to assist in connection of two sections.

1000 Sections jacked up and set on additional dunnage to aid connection.

1008 Two sections pulled together, jacked, then pinned. Assembly completed.

1215 Practice removing two modules, one of which is a ramp, at a time. Removed skates from ramp (required dunnage, jacks, comealongs, and crane).

1310 Skates removed. Begin lowering ramp to alternate position.

1330 Dunnage in place to lower ramp.

1400 Ramp lowered in steps using dunnage, bottle jacks.

1400 Meeting to discuss August ELCAS RO/RO operation.
LT Johnson, LT Williams, LT Groff, and CMC Noel from ACB-2.
B. Karrh, P. Kane, and S. Oppedisano from NCEL.
Johnson comments on Giannotti and Associates mooring design: Beach CPF in SS4. Do not try an emergency moor or leave at end of ELCAS. Believes it would only take one-half hour to slip moor. Would want buoy at transition between chain and hawser on anchor mooring leg. Would rather use wire rope than hawser because of boat propellers. Would require five craft for 40' offset (4 to hold, 1 to set anchors) and four craft for 6' offset (3 to hold, 1 to set anchors).
Agreed upon mooring scenario after much debate.

APPENDIX C

PHASE II TEST NOTES

SUN 29 JUL 90

All sections elevated except No. 13 and roadway section near beach. Inspected RO/RO platform at NAB, Little Creek. Dunnage not level - should restack. Bolts missing from upper section.

MON 30 JUL 90

Pile guides welded on top of shear connectors of the two outboard sections of the three section wide ELCAS pierhead. Pile guides were modified by adding 3/4-inch plate fully inside of brackets. CMC Noel said that they would cut out 22" dia. hole to hold 20" dia. pile.
Four 20" dia. piles installed in pile guide. Driven but not to resistance. Average length of pile is 65'.
PO Doyle preparing water washdown unit for use with P-250.
Inspected LMMSA bridge beam. PHIBCB's torched third pin hole instead of drilling it. UNSAT. Will have to come up with procedure to fix it. May need to cut out square around hole and replace with a plate with predrilled hole (or no predrilled hole).

TUE 31 JUL 90

0800	Second set of sacrificial pile being installed.
1000	Pile installation complete. RO/RO platform arrives with fender string alongside.
1100	Fender string brought along side of ELCAS and piles inserted in fender string spudwells. CPF already moored alongside fender string.
1130	Crane lift to center of CPF measured to be approximately 58'. (44' from CPF center to center of fender pile + 14' from center of fender pile to crane's center of pivot). Crane lift capability at 60' is 42,800 lbs. Subtract 5,000 lbs. for block. 37,800 lbs. available to lift LMMSA.
1330	Moving 140-ton crane onto ELCAS.
1620	Counterweight installed on crane. Ready to assemble LMMSA.
1730	Truck w/ two LMMSA modules driven onto ELCAS.
1735	140-ton crane in place for 3-long LMMSA lift.
1800	Ramp module opened and braced, ready to pin to bridge beam.
1820	Bridge beam pinned to ramp w/ 5 pins.
1835	Ramp module angle set to down position.
1915	Parallel module connected to ramp module.
1937	Second parallel module connected to first parallel module.
2000	Three section lift ready. Uneven lift resulted because sling with legs of different lengths to compensate for uneven weight distribution (ramp end with bridge beam heavier) was not made.

2020 Three section on deck of CPF.
2100 Second ramp module opened.
2110 Bracing beam installed in ramp module.
2120 First parallel for second assembly opened.
2140 First skate assembly pinned to ramp module.
2155 Second skate assembly pinned to ramp module.
2215 First parallel module ready for connection to ramp module.
2225 First parallel module connected to ramp module. PHIBCB's connected bottom pins first, then high tension link and shootbolts.
2235 Last parallel module lowered to ELCAS deck. Chain clutch removed from module end.
2300 Last parallel module opened.
2310 Last parallel module connected to first parallel module. Once again the bottom pins installed first, then top pins.
2330 Due to wind gusts between twenty and thirty miles per hour, the three-long section lift was determined unsafe and was postponed until the following day.

WED 1 AUG 90

0230 The SLWT on site for tending the CPF sank. The SLWT was at anchor near the shore. When the weather picked up the SLWT was going to reposition. The SLWT took in wire on its stern winch drum trying to bring in the stern anchor. The stern anchor did not free and the scope of the anchor wire was sufficiently reduced that the wave surge caused waves to break over the SLWT's stern. The engine hatch covers were not properly secured resulting in the SLWT taking on water and sinking.

ACB-2 spent the rest of the day trying to salvage the SLWT with the Army's LARC-LX and bulldozers.

Because of a lack of tender boat availability, ELCAS RO/RO testing rescheduled for Fri 3 Aug, weather permitting.

THU 2 AUG 90

Because of a lack of tender boat availability, ELCAS RO/RO testing was rescheduled for 7 Aug (9 Aug alternate date). SLWT refloated and towed back to Desert Cove along with the RO/RO platform.

FRI 3 AUG 90

The 3-module LMMSA assembly was disassembled and transported to the RO/RO platform at Desert Cove for assembly. These modules were individually connected to the three-long LMMSA assembly already on the RO/RO platform.

SAT 4 AUG 90

Trials of the water washdown hardware with the P-250 pump were conducted. Problems experienced with priming of the P-250, since pump was on ELCAS about 15 feet above water. Used fire hose to distribute water to a nozzle made by cross saw cut on end cap of a 2-inch diameter PVC pipe.

SUN 5 AUG 90

No work performed.

MON 6 AUG 90

Demonstration of donning and removal of CBR suits by ACB safety personnel. Discussed CBR demo plan with Battelle. USMC instructors demonstrated use of SANATOR 17 decontamination unit.
Problems with clearance for testing of chemical simulant. Met with Lt. Mc Keithen of USA Ft. Story Operations. They cannot get anyone to approve use of simulant. Various waterway control agencies would not give explicit approval of test. Ft. Eustis environmental personnel cited simulant as unharmful to environment (especially with the small amount to be used in the demo), but did not recommend that test be performed. Ft. Story would not approve without explicit recommendation, even after CDR Stryker said he would take responsibility.
Mtg. - Plan to depart Desert Cove with RO/RO at 0300 7 Aug. LT Thornton to judge if weather ok for CPF to leave Desert Cove with tender boats.

TUE 7 AUG 90

0445 CPF departed Desert Cove.

0730 CPF approaching ELCAS. Slack low tide, no wind. Waves less than 2 feet. 140-ton crane set up to lift LMMSA.

0745 LMMSA end which was overhanging end of CPF collided with ELCAS sacrificial piling on starboard side. Tender craft missed their mark. The LMMSA should be pulled back after assembly for protection in future operations.

0750 Criss-cross mooring lines passed from ELCAS to CPF. Lines were 1-1/8 inch diameter wire rope with no possibility of adjusting length. One was too long, the other too short. Both were connected into the outboard FLEXOR connector slots on the ELCAS and in the inboard connector slots of the outboard CPF sections.

0800 Criss-cross line installation complete. Noted that outboard edge of pile guides could strike the fenders if high waves or high tide encountered.

0805 Longitudinal mooring lines passed from CPF to inflatable which then pulled them underneath the ELCAS. These eight inch double braid lines were shackled to wire rope that were connected around the double angles at the beach end of Sections 12 and 13.

0815 First 3,000-lb. aft mooring anchor installed by SLWT. SLWT lifted it from CPF deck with A-frame. The anchor's crown wire was spooled onto the SLWT winch. The SLWT then maneuvered into place.

0830 The crown wire was removed from the SLWT winch and a crown buoy was installed.

Separation of rubber pads on LMMSA skate footing noted. Found out from PO Barrett that separation happened when LMMSA collided with the ELCAS piles. ACB's had pre-rigged the comealongs to pull footing. The collision moved LMMSA about 2 feet and the comealong wire pulled taut on the skate assembly, separating the rubber pads.

0900 Second anchor lifted from CPF deck.

0910 Second anchor set in place and crown buoy installed.

0915 LMMSA bridge lifting beam connected to 140-ton crane hook.

0917 LMMSA lifted. 8,000 lb. wire rope comealongs used to pull LMMSA toward ELCAS until interface hardware was aligned. Crane readout of lift: 41,000 lbs. at 43' radius, 90' boom. Weight includes 5,200 lb. block and rigging. Allowed 70,000 lbs.

Crane's end was sitting on middle of fourth pontoon can from seaward end of ELCAS. 37 degree boom angle to end of ELCAS.

0920 LMMSA installed and mating beams shackled.

0930 PHIBCB's ready to lift and remove LMMSA. CMC Noel said it would take about 30 minutes to set up 140-ton crane to remove LMMSA if it started out on Section 11.

0934 LMMSA lifted. Comealongs used to pull LMMSA away from ELCAS. Long period waves from passing ship caused LMMSA to swing on crane hook. Precarious operation because CPF moved out of place in the moor. The cross moor lines were slack and did not hold moor in line. No damage.

0937 LMMSA set on CPF deck

0940 Comealongs rigged on side of LMMSA near base to move it sideways. During the wave motion the LMMSA shifted sideways. LMMSA slid back in place.

1002 LMMSA lifted by 140-ton crane with bridge lifting beam. Comealongs used to pull LMMSA toward ELCAS.

1009 LMMSA installed and mating beams shackled. 18' from ELCAS deck to water surface. Low tide.

1030 140-ton crane moved off of center pierhead section. 30-ton crane positioned for positioning beach ramp.

1040 Beach ramp lifted.

1055 Beach ramp set in place on ELCAS deck at seaward end of LMMSA.

1113 Turntable ramp lifted off of floating admin barge w/ 60-ton crane.

1125 Forklift set turntable ramp at end of beach ramp.

1130 Tractor-trailer on floating section which was end connected to CPF driven up and over LMMSA ramp. Driven down ELCAS roadway where it turned around and came back.

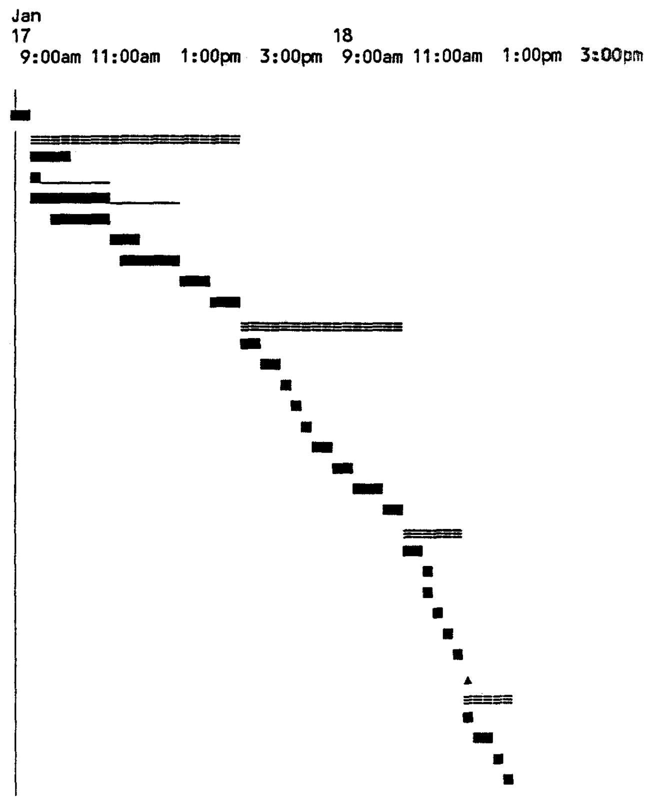
1138 Tractor-trailer driven down LMMSA ramp and onto CPF.

1143	Finger ramps removed from LMMSA. Comealongs had already been rigged for extraction of LMMSA. Wind 10-12 mph northerly. SS1 to low end of SS2.
1145	Turntable ramp removed with 30-ton crane
1152	Beach ramp removed with 30-ton crane. Slack tide coming off of high tide. Installed at low tide. Wind picked up to 10-12 mph. Estimated SS 1+ or 2- from N.
1158	30-ton crane moved off of ELCAS. Per LT Thornton: 2 CSP's or SLWT's and 4 tender boats would be required to install CPF at seaward end of ELCAS.
1207	140-ton crane moved back into place. Outriggers sets.
1209	140-ton crane operational.
1213	Bridge lifting beam set on crane hook.
1214	Bridge lifting beam hooked to LMMSA.
1217	LMMSA lifted and wire rope comealongs used to pull LMMSA away from ELCAS.
1221	LMMSA set on CPF deck.
1224	Port cross mooring line released.
1230	LMMSA strapped to CPF deck.
1233	Down current anchor removed by SLWT.
1235	Down current anchor set on CPF deck.
1237	Down current longitudinal line slacked.
1240	Down current longitudinal line removed from ELCAS.
1250	Second longitudinal line removed from ELCAS.
1253	CPF moved away from ELCAS. Second anchor line kicked overboard off of CPF. Second anchor then retrieved by SLWT.
1300	CPF on way back to ACB-2's Desert Cove.

APPENDIX D

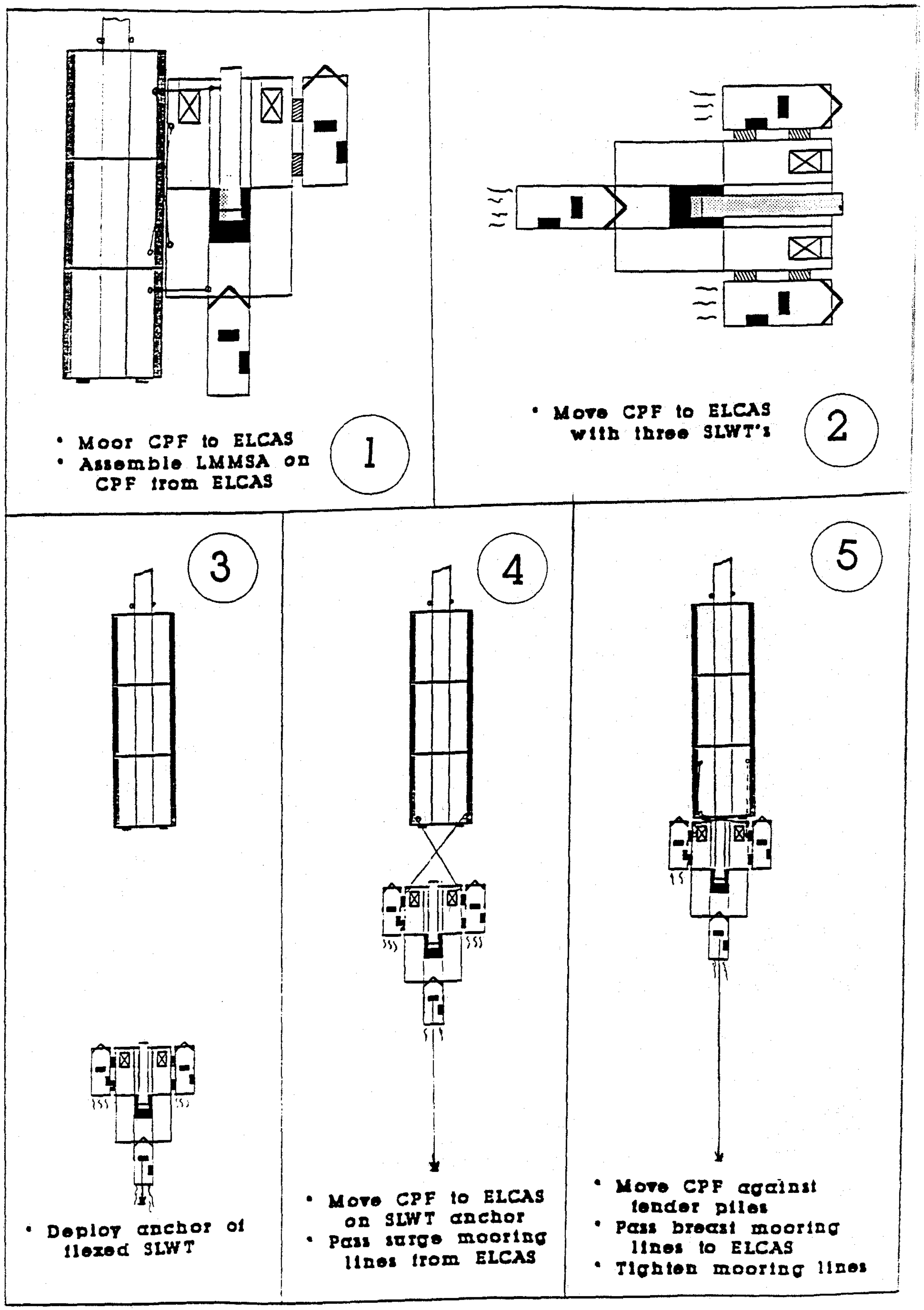
RECOMMENDED INSTALLATION PROCEDURE

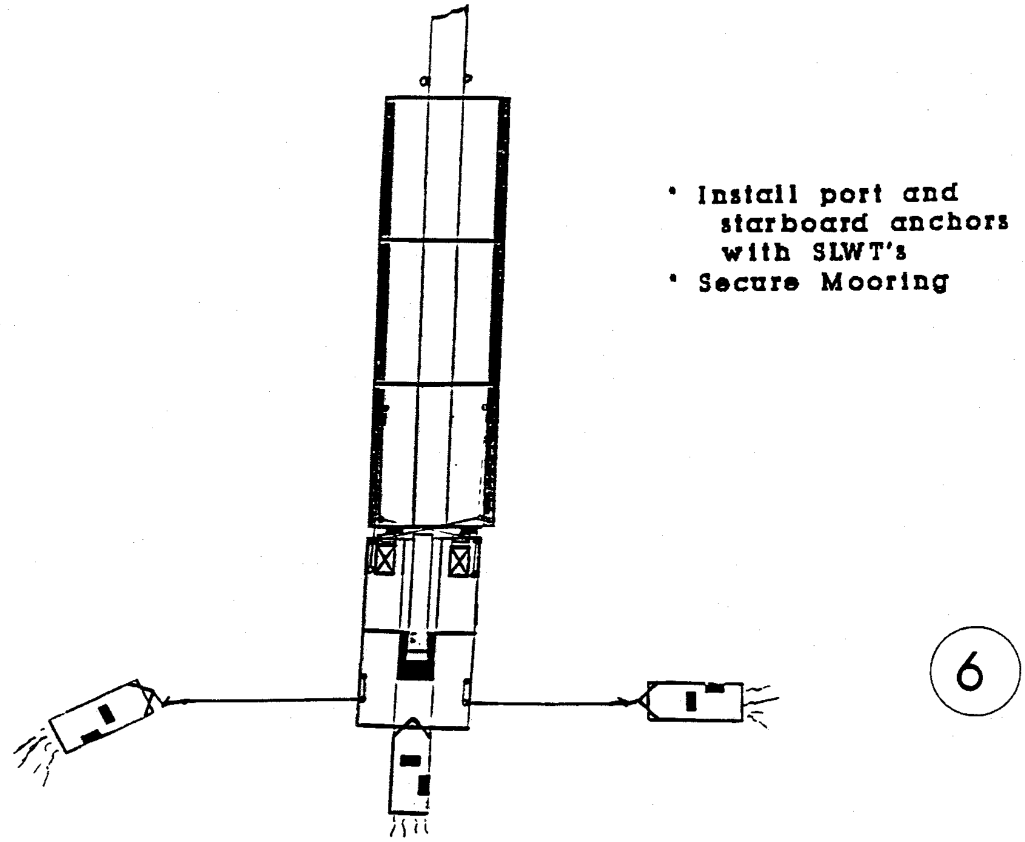
WBS	Task Name	Dur
0	START	0.0
1	MOOR CPF TO ELCAS	30.0
2	CONSTRUCT LMMSA ON CPF	5.2
2.2	STAGE MODULES ON ELCAS	1.0
2.3	PLACE DUNNAGE ON CPF	15.0
2.1	BUILD FOOTING ON CPF	2.0
2.4	ASSEMBLE 3-MODULE LMMSA	1.5
2.5	XFER 3-MOD LMMSA TO CPF	45.0
2.6	ASY 3-MOD LMMSA #2	1.5
2.7	XFER 3-MOD #2 TO CPF	45.0
2.8	CONNECT 3-MOD LMMSA's	45.0
3	MOOR CPF @ END OF ELCAS	4.0
3.1	FLEX SLWT TO CPF	30.0
3.2	TIE LIGHTERS TO CPF	30.0
3.3	APPROACH END OF ELCAS	15.0
3.4	DEPLOY FLEX SLWT ANCHOR	15.0
3.5	MOVE CPF TO ELCAS	15.0
3.6	DEPLOY SURGE LINES TO CPF	30.0
3.7	DEPLOY BREAST LINES TO CP	30.0
3.8	DEPLOY P/S CPF ANCHORS	45.0
3.9	SECURE MOORING	30.0
4	INSTALL LMMSA TO ELCAS	1.5
4.1	STAGE 140 TON CRANE	30.0
4.2	RIG CRANE FOR LMMSA LIFT	15.0
4.3	RIG COMEALONGS ON CPF	15.0
4.4	LIFT LMMSA TO ELCAS	15.0
4.5	REMOVE 140 TON CRANE	15.0
4.6	INSTALL LMMSA TRANSITIONS	15.0
5	PERFORM RORO OPS	0.0
6	REMOVE EL-RORO	1.3
6.1	REMOVE TRANSITION RAMPS	15.0
6.2	STAGE 140 TON CRANE	30.0
6.3	LOWER LMMSA TO CPF	15.0
6.4	REMOVE CPF FROM MOOR	15.0

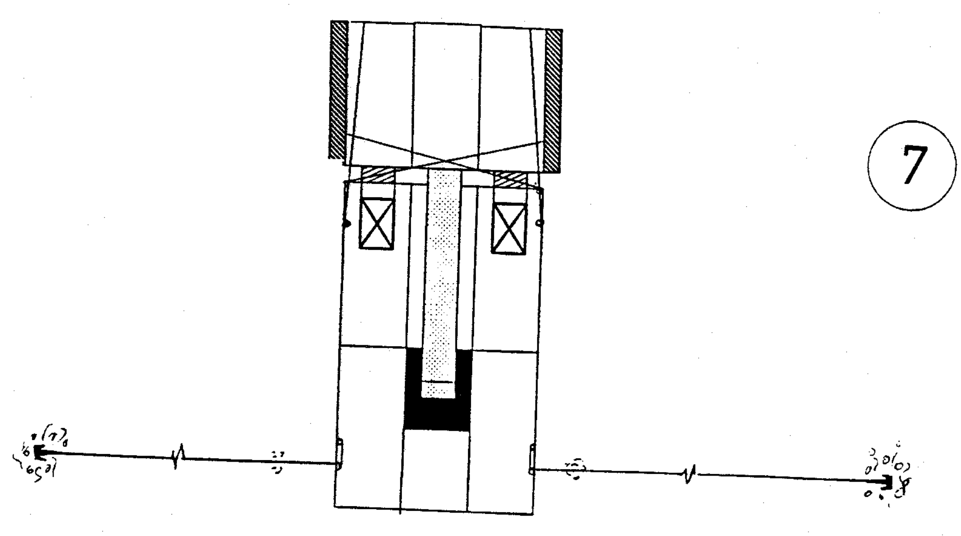


Detail Task · Summary Task · ▲ Milestone
(Started) · (Started) · ►►► Conflict
(Slack) · (Slack) · .. Resource delay

Scale: 15 minutes per character


1
• Moor CPF to ELCAS
• Assemble LMMSA on CPF from ELCAS
2
• Move CPF to ELCAS with three SLWT's
3
• Deploy anchor of flexed SLWT
4
• Move CPF to ELCAS on SLWT anchor
• Pass surge mooring lines from ELCAS
5
• Move CPF against fender piles
• Pass breast mooring lines to ELCAS
• Tighten mooring lines





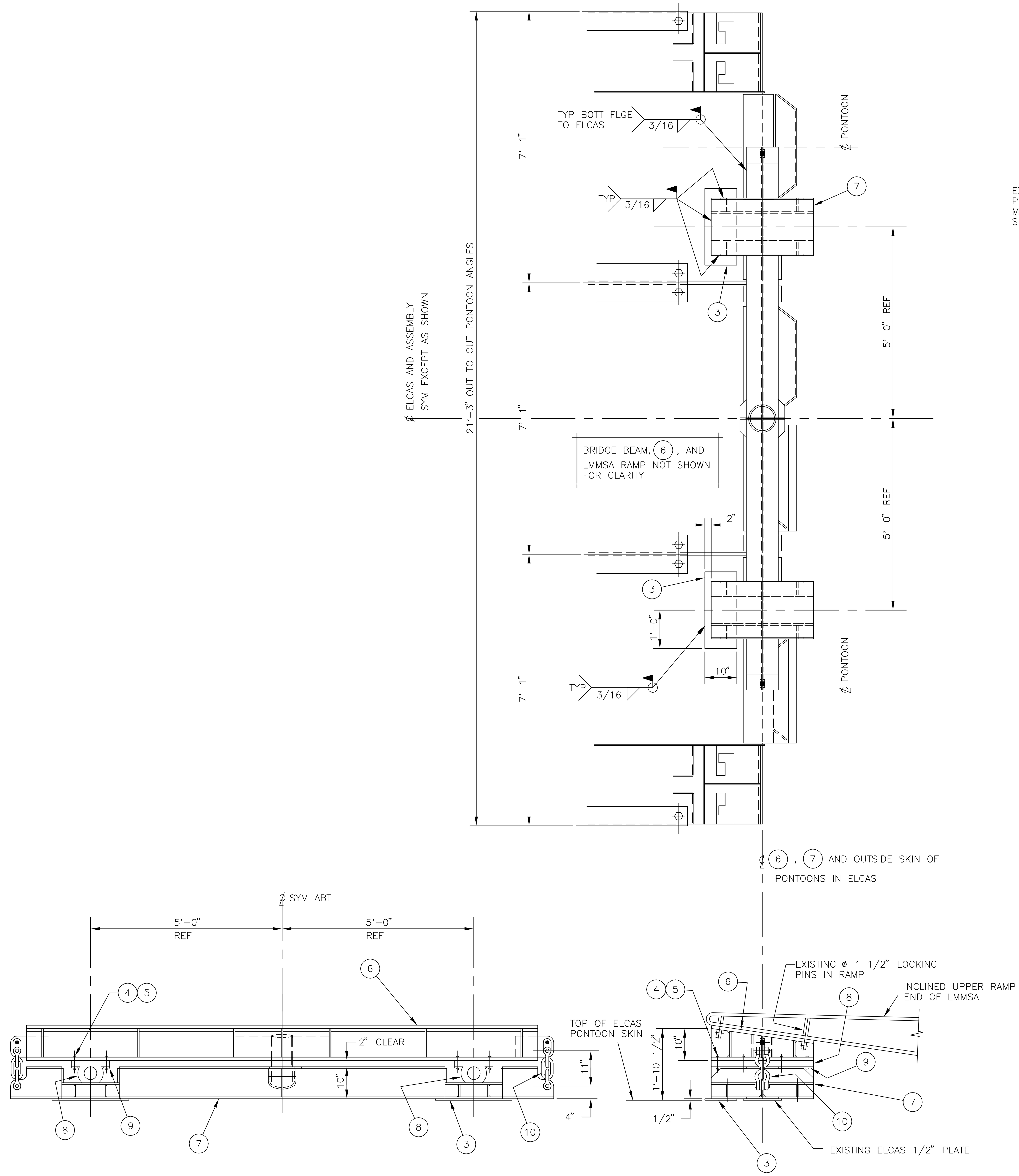
RDF MOORING COMPLETE

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

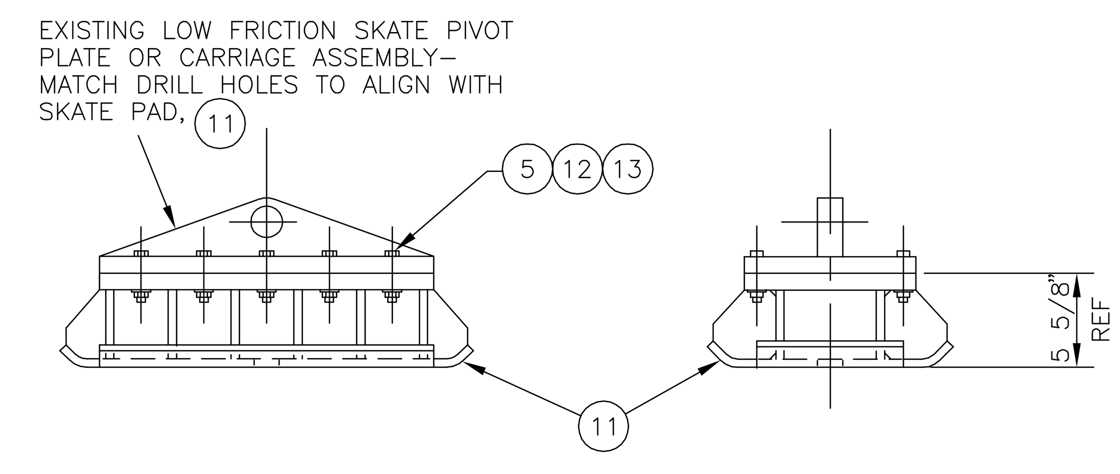
NOTES

1. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
2. THE FOLLOWING EXISTING LMMSA DRAWINGS HAVE BEEN USED TO ASSIST IN THE DEVELOPMENT OF THE ASSEMBLIES SHOWN ON THIS DRAWING.

NAVFAC DWG NO	TITLE
6275769	LOW FRICTION SKATE, CARRIAGE ASSEMBLY
6275770	LOW FRICTION SKATE, CARRIAGE WELDED ASSEMBLY
6275771	LOW FRICTION SKATE, DETAILS
6275772	LOW FRICTION SKATE, ASSEMBLY
6275774	INCLINED RAMP UPPER BEARING
6275775	GENERAL ARRANGEMENT OF INCLINED RAMP FROM FLOATING PLATFORM TO PIER HEAD



1 LMMSA-ELCAS ASSEMBLY



2 SKATE ASSEMBLY

TYPICAL 8 PLACES

-2	-1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
80		13	90-2-1F-7	WASHER, HARDENED STEEL FINISHED, 1 1/8" OD X 17/32" ID X 1/8" THICK	
80		12	90-2-1F-6	CAP SCREW, 1/2"ø-13NC X 2 3/4", HEX HD, ZINC CHROMATE, GRADE 5	
8		11	90-2-4F-1	SKATE PAD	
	2	10	90-2-4F-8	LINK TIE-DOWN	
	4	9	90-2-4F-7	FENDER PLATE	
	2	8	90-2-4F-6	WING-TYPE FENDER, RUBBER 8" X 12"	
	1	7	90-2-3F-1	FOUNDATION BEAM	
	1	6	90-2-2F-1	BRIDGE BEAM	
80	16	5	90-2-1F-5	NUT, 1/2"ø-13NC, SELF LOCKING HEX, ZINC PLATED THIN HEIGHT	
	16	4	90-2-1F-4	CAP SCREW, 1/2"ø-13NC X 4", HEX HD, ZINC CHROMATE GRADE 5	
	2	3	90-2-1F-3	PLATE 1/2" X 10" X 2'-0", ASTM A36	
X		2	90-2-1F-2	SKATE ASSEMBLY	
	X	1	90-2-1F-1	LMMSA-ELCAS ASSEMBLY	
QUANTITY FOR EACH ASSEMBLY		PARTS LIST			

PART DASH NO.	NEXT ASSY.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ± 1/16"
ANGLES

PROJ NO
NCEL DWG. NO. 90-2-1F
DES K.MACK | DR K.MACK 3/90
CHK C.GARCIA
DIV DIR M.STERN
DEPT HEAD
SATISFACTORY TO P.KANE
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

LMMSA

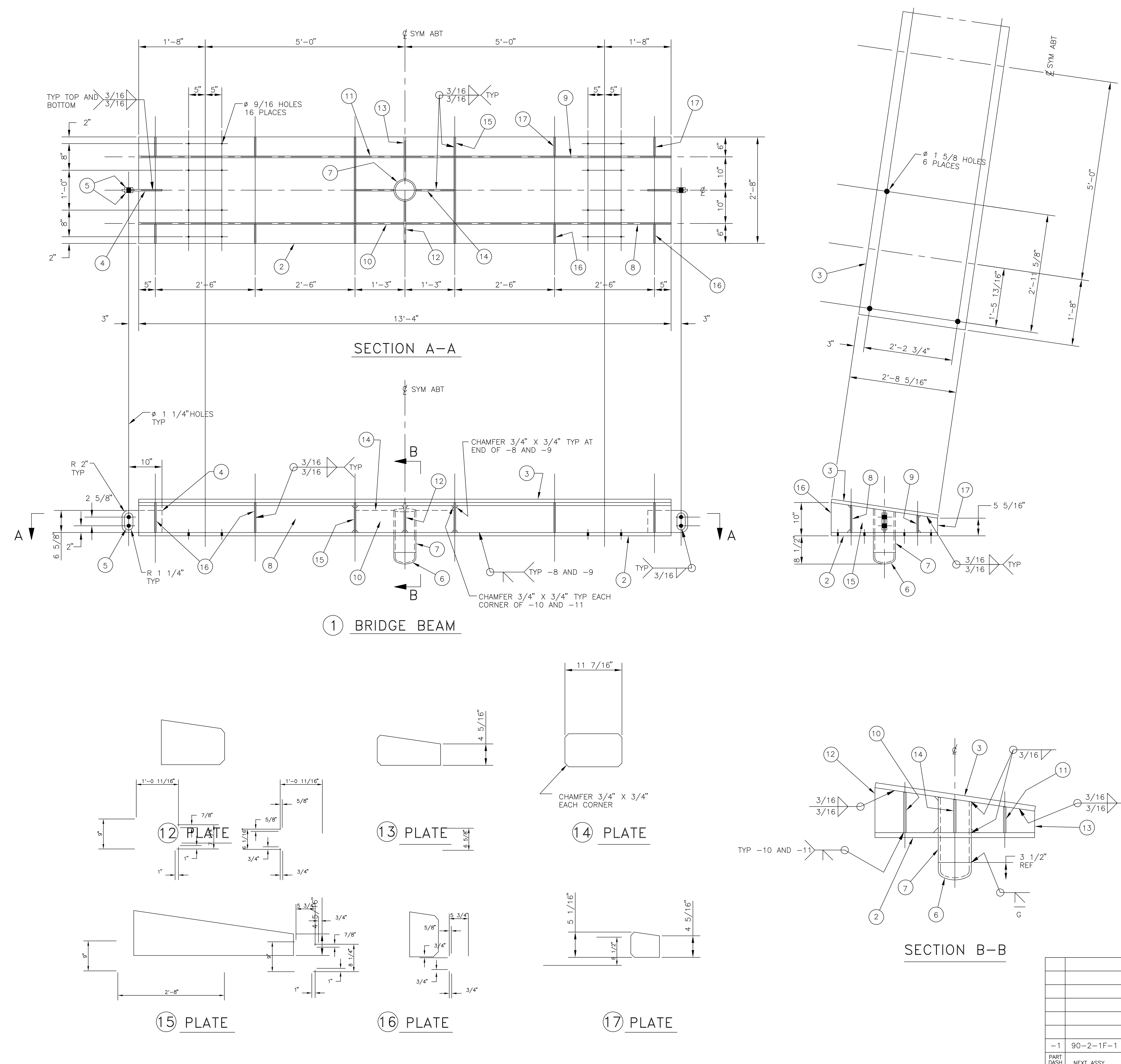
LMMSA-ELCAS ASSEMBLY SKATE ASSEMBLY

SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 1 OF 4

IF IN DOUBT, ASK - DO NOT SCALE

J89-22(L650129)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



SECTION A-A

1 BRIDGE BEAM

SECTION B-B

12 PLATE

13 PLATE

14 PLATE

15 PLATE

16 PLATE

17 PLATE

NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
3. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.

QTY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
4	17	90-2-2F-17	PLATE 1/2" X 5 1/16" X 0'-5 3/4"	
4	16	90-2-2F-16	PLATE 1/2" X 5 3/4" X 0'-9"	
2	15	90-2-2F-15	PLATE 1/2" X 9" X 2'-8"	
2	14	90-2-2F-14	PLATE 1/2" X 6 5/8" X 0'-11 7/16"	
1	13	90-2-2F-13	PLATE 1/2" X 6 1/16" X 1'-0 11/16"	
1	12	90-2-2F-12	PLATE 1/2" X 9" X 1'-0 11/16"	
2	11	90-2-2F-11	PLATE 1/2" X 5 1/8" X 1'-2 1/2"	
2	10	90-2-2F-10	PLATE 1/2" X 8 1/16" X 1'-2 1/2"	
2	9	90-2-2F-9	PLATE 1/2" X 5 1/8" X 5'-4 3/4"	
2	8	90-2-2F-8	PLATE 1/2" X 8 1/16" X 5'-4 3/4"	
1	7	90-2-2F-7	PIPE 6"XS X 1'-1 1/16" ,SCH.80, ASTM A53 GR.B	
1	6	90-2-2F-6	WELDED PIPE CAP 6"XS(EXTRA STRONG) , ASTM A234	
4	5	90-2-2F-5	PLATE 1/2" X 2 1/2" X 0'-5 1/8"	
2	4	90-2-2F-4	PLATE 1/2" X 6 5/8" X 1'-0"	
1	3	90-2-2F-3	PLATE 1" X 32 5/16" X 13'-4"	
1	2	90-2-2F-2	PLATE 1" X 32" X 13'-4"	
	1	90-2-2F-1	BRIDGE BEAM	
-1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
QUANTITY FOR EACH ASSEMBLY			PARTS LIST	

-1	90-2-1F-1
PART DASH NO.	NEXT ASSY.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ± 1/16"
ANGLES

PROJ NO
NCEL DWG. NO. 90-2-2F
DES K.MACK | DR K.MACK 3/90
CHK C.GARCIA
DIV DIR M.STERN
DEPT HEAD
SATISFACTORY TO P.KANE
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

LMMSA
BRIDGE BEAM

SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 2 OF 4

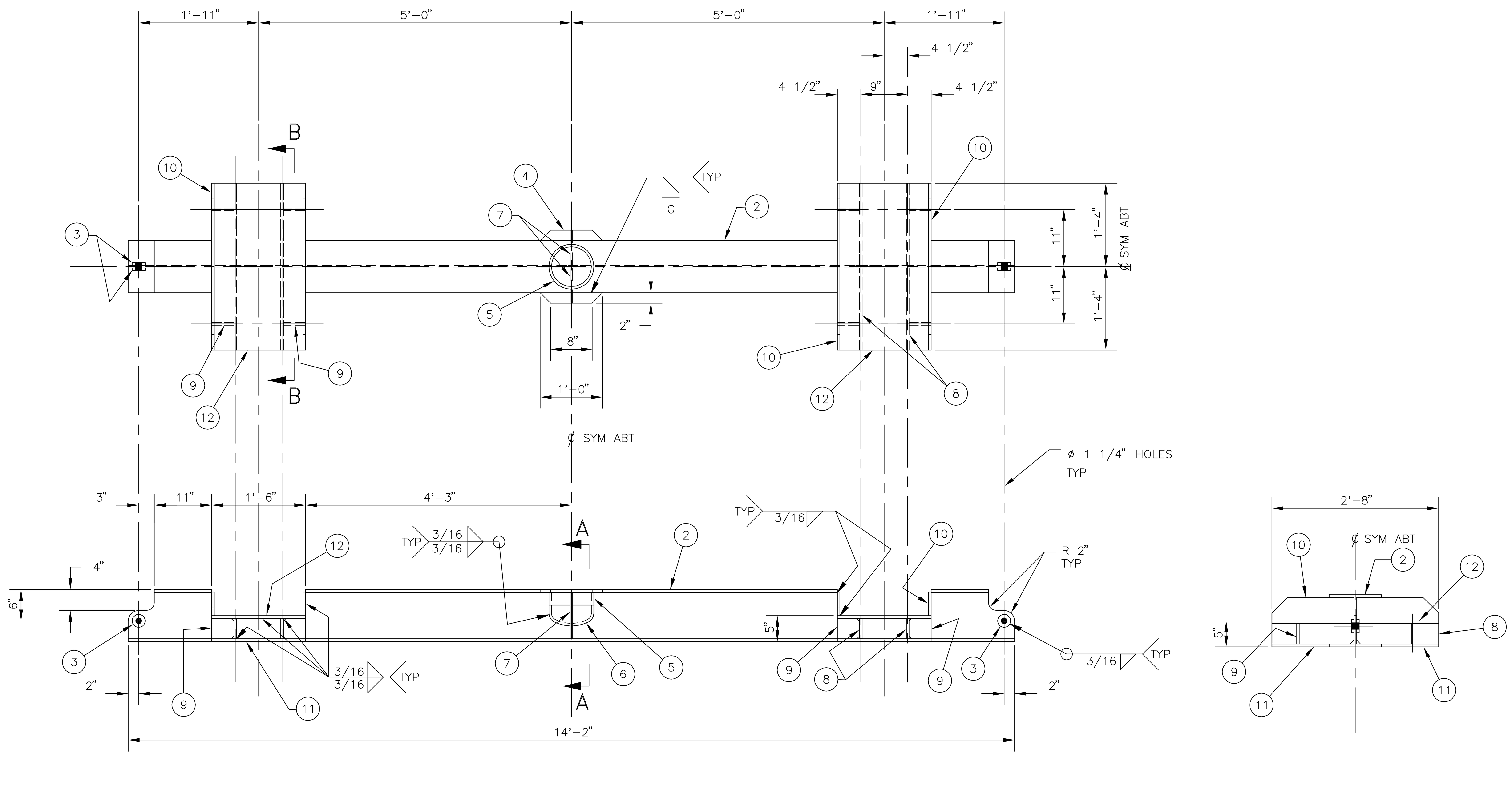
IF IN DOUBT, ASK — DO NOT SCALE

J89-22(L650129) REV 1

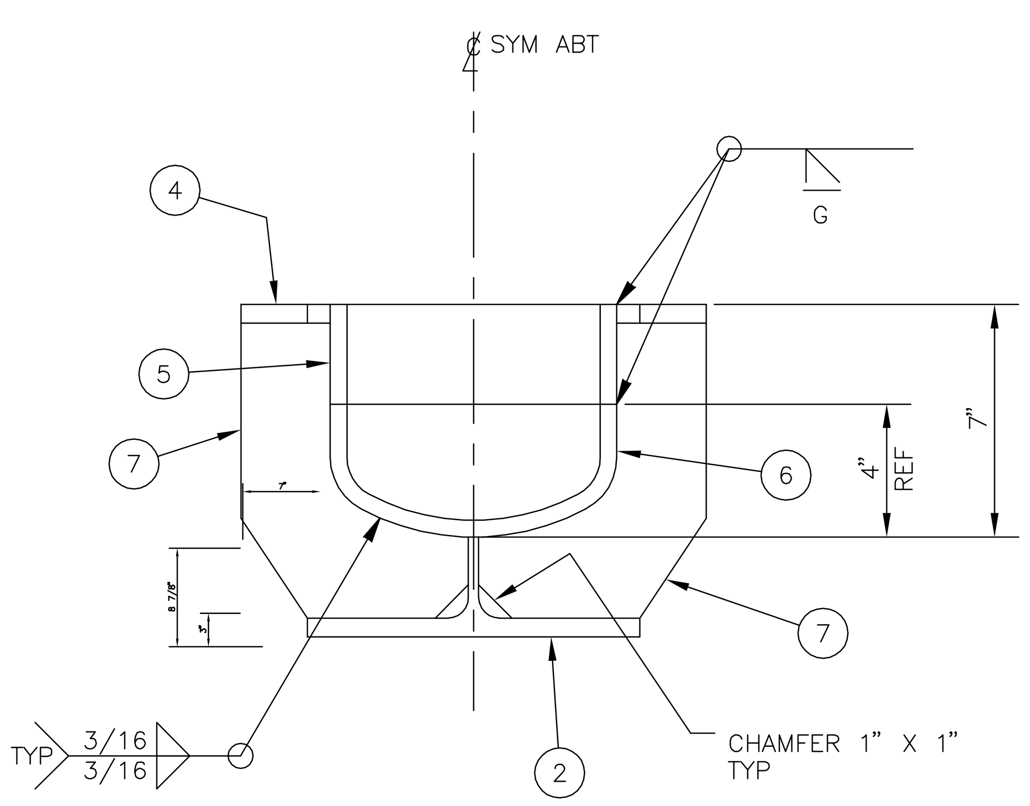
REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

NOTES

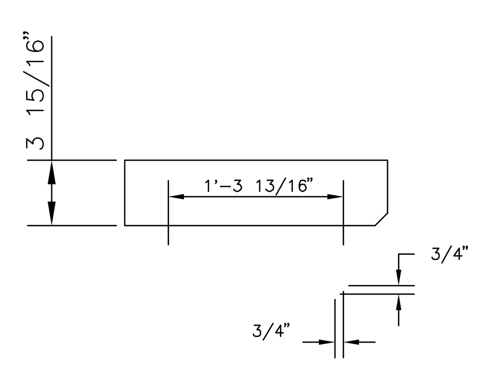
1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
3. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.



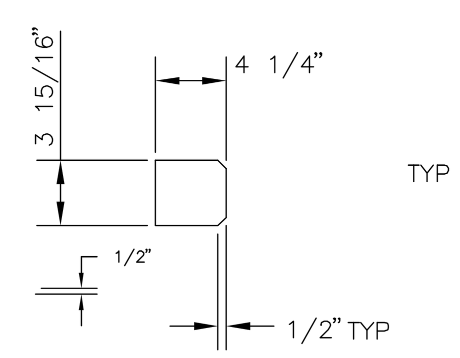
1 FOUNDATION BEAM



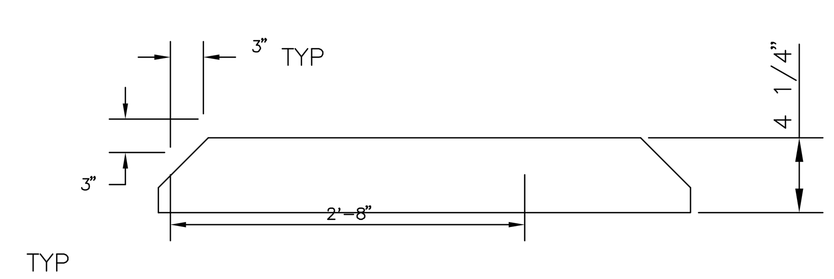
SECTION A-A



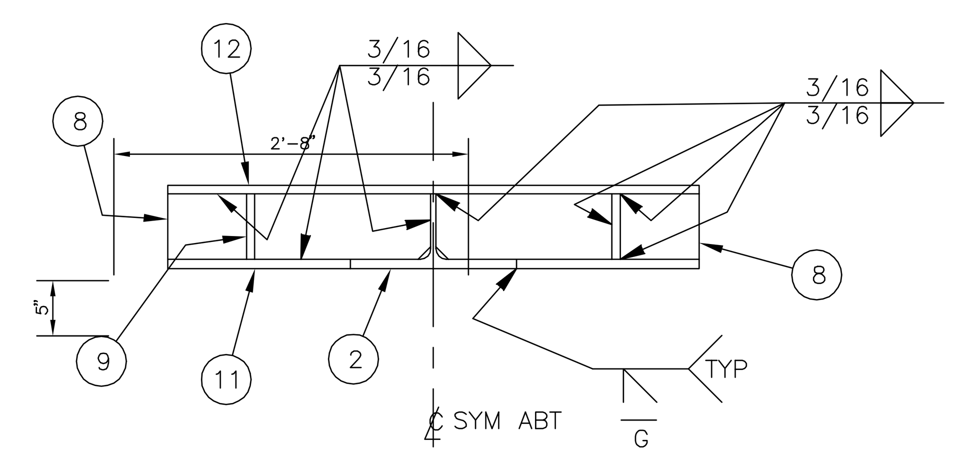
8 PLATE



9 PLATE



10 PLATE



SECTION B-B

QTY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
2	12	90-2-3F-12	PLATE 1/2" X 18" X 2'-8"	
4	11	90-2-3F-11	PLATE 9/16" X 11" X 1'-6"	
4	10	90-2-3F-10	PLATE 1/2" X 4 1/2" X 2'-8"	
8	9	90-2-3F-9	PLATE 1/2" X 3 15/16" X 0'-4 1/4"	
8	8	90-2-3F-8	PLATE 1/2" X 3 15/16" X 1'-3 13/16"	
2	7	90-2-3F-7	PLATE 1/2" X 6 13/16" X 0'-8 7/8"	
1	6	90-2-3F-6	WELDED PIPE CAP 8"XS(EXTRA STRONG) , ASTM A234	
1	5	90-2-3F-5	PIPE 8"XS X 0'-3" , SCH.80, ASTM A53 GR B	
2	4	90-2-3F-4	PLATE 9/16" X 2" X 1'-0"	
4	3	90-2-3F-3	PLATE 1/2" X 2 1/2" ϕ	
1	2	90-2-3F-2	W10 X 49 X 14'-2"	
X	1	90-2-3F-1	FOUNDATION BEAM	
-1 (QUANTITY FOR EACH ASSEMBLY)	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL

PARTS LIST

PART DASH NO.	NEXT ASSY.
-1	90-2-1F-1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES
TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ± 1/16"
ANGLES

PROJ NO
NCEL DWG. NO. 90-2-3F
DES K.MACK | DR K.MACK 3/90
CHK C.GARCIA
DIV DIR M.STERN
DEPT HEAD
SATISFACTORY TO P.KANE
APPROVED | DATE
COMMANDING OFFICER
APPROVED | DATE
FOR COMMANDER, NAVFAC

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

LMMSA
FOUNDATION BEAM

SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO | CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 3 OF 4

IF IN DOUBT, ASK - DO NOT SCALE

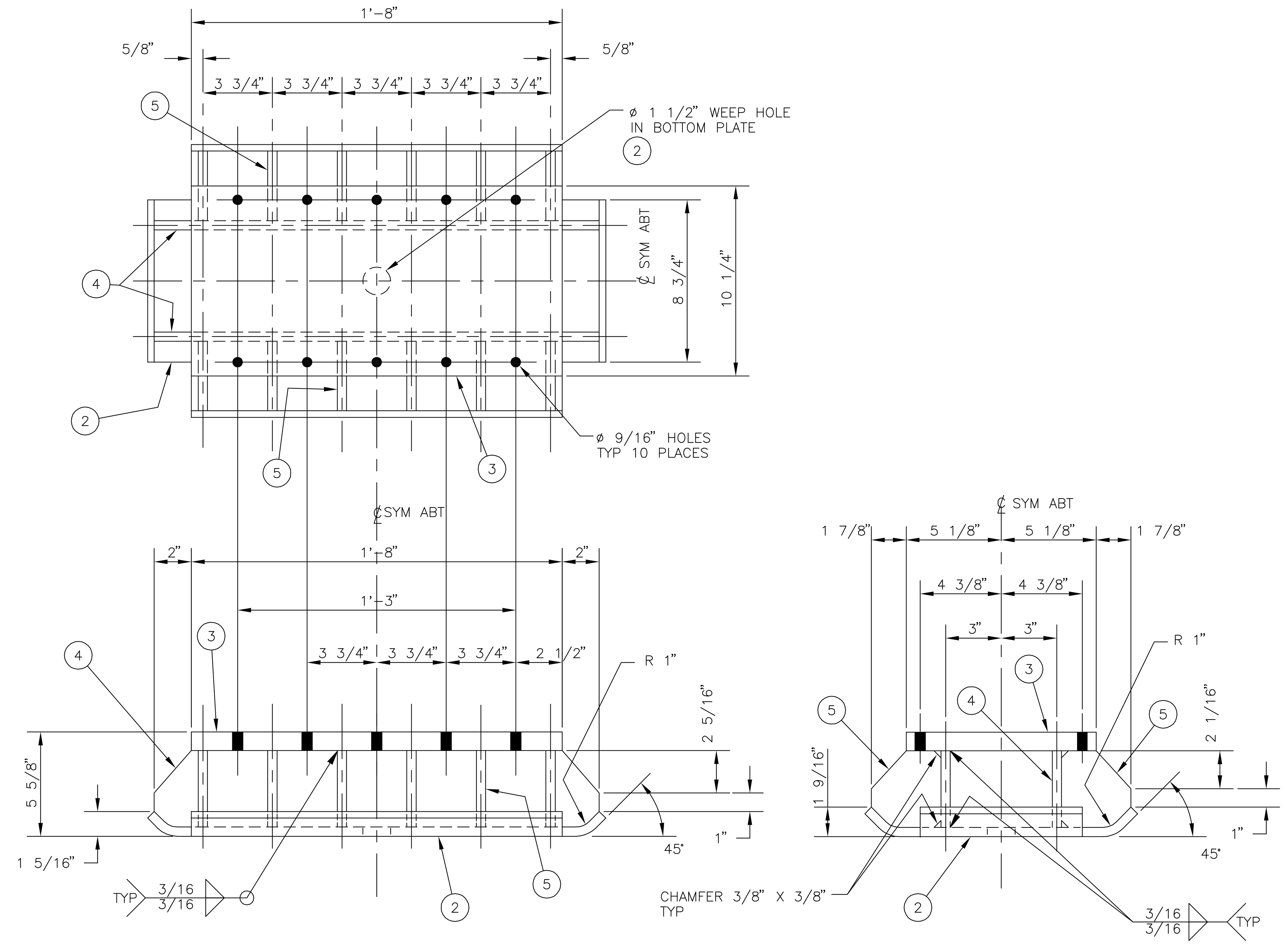
J89-22(L650129)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

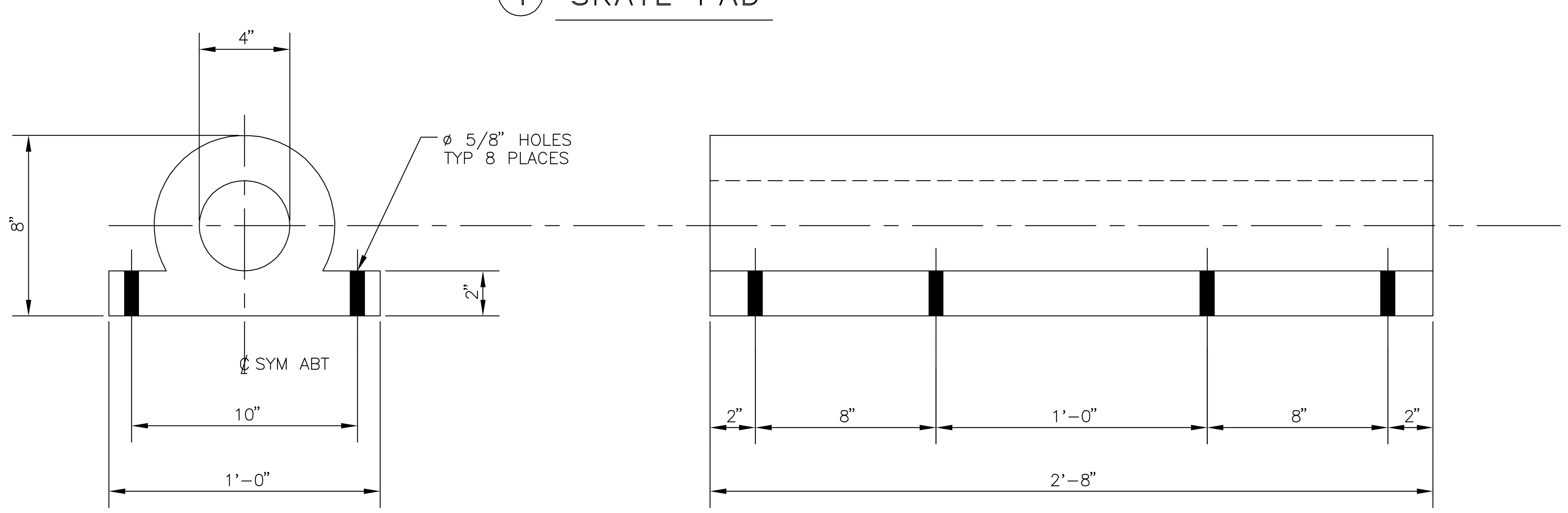
NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A240 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED. (STAINLESS STEEL TYPE 316L)
2. USE AWS A5.9–81 EWP ELECTRODES OR 316L FILLER METAL FOR ALL WELDS.
3. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
4. THE RUBBER WING–TYPE FENDER SHALL CONFORM TO ASTM D–2000/ SAE J200: 3BA 720 A14,B13,D11,F17,L11 OR 4CA 720 C32,F19,G11,L14 .

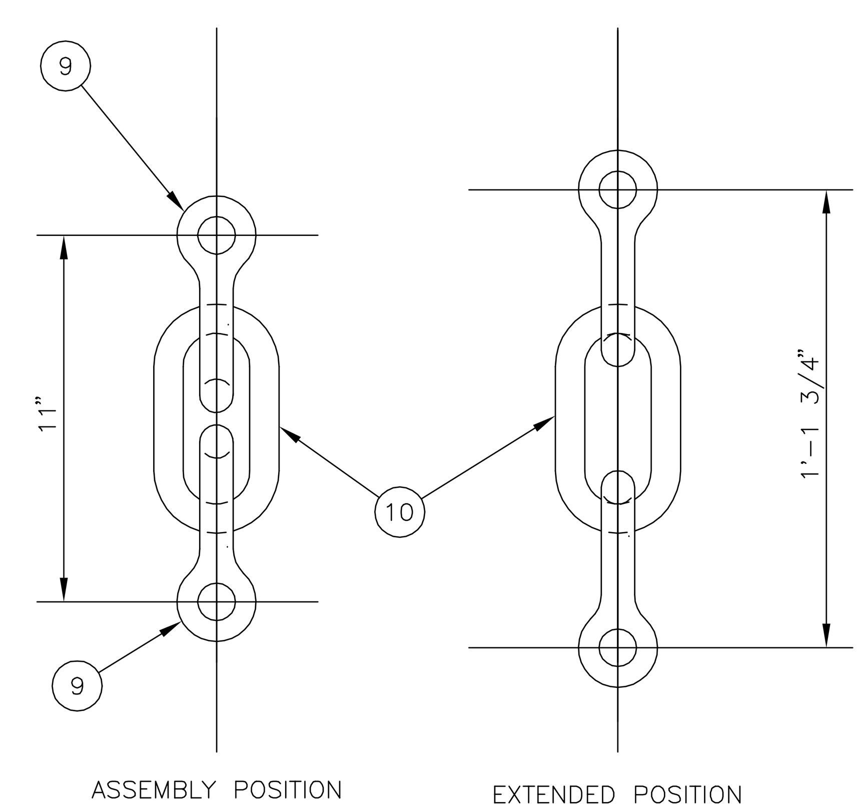
   2000 PSI MINIMUM TENSILE STRENGTH
   70 DUROMETER HARDNESS



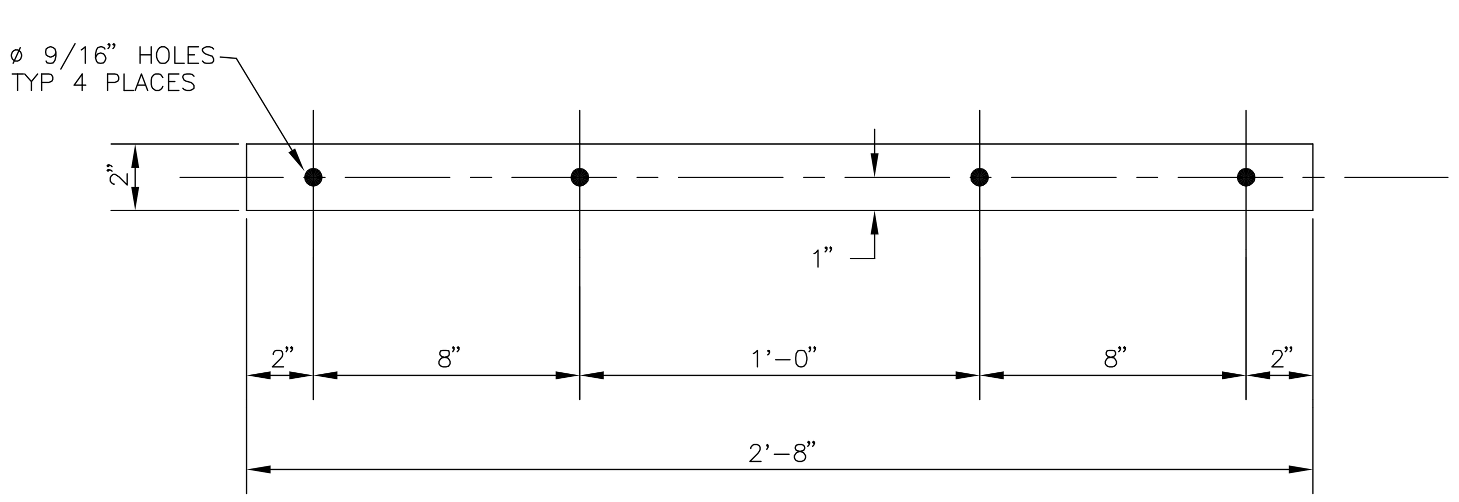
(1) SKATE PAD



(6) WING–TYPE FENDER



(8) LINK TIE–DOWN



(7) FENDER PLATE

-8	-7	-6	-1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
1				10	90–2–4F–10	7/8"ø WELDLESS END LINK, FORGED STEEL, W.L.L.=12 K FED.SPEC. RR–C–271B, TYPE VI	
2				9	90–2–4F–9	1"ø ANCHOR SHACKLE, SCREW PIN, W.L.L.=17 K FED.SPEC. RR–C–271B, TYPE IV, CLASS 1	
X				8	90–2–4F–8	LINK TIE–DOWN	
	X			7	90–2–4F–7	FENDER PLATE, 3/8" X 2" X 2'–8", ASTM A36	
		X (4.)		6	90–2–4F–6	WING–TYPE FENDER , RUBBER 8" X 12"	
			12	5	90–2–4F–5	PLATE 1/2" X 3 3/4" X 0'–4 1/8"	
			2	4	90–2–4F–4	PLATE 1/2" X 4 1/8" X 2'–0"	
			1	3	90–2–4F–3	PLATE 1" X 10 1/4" X 1'–8"	
			1	2	90–2–4F–2	PLATE 1/2" X 15 3/16" X 2'–1"	
			X	1	90–2–4F–1	SKATE PAD	

QUANTITY FOR EACH ASSEMBLY

PARTS LIST

PART DASH NO.	NEXT ASSY.
–8	90–2–1F–1
–7	90–2–1F–1
–6	90–2–1F–1
–1	90–2–1F–2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ± 1/16"
ANGLES ± 0°–30'

PROJ NO
NCEL DWG. NO. 90–2–4F
DES K.MACK DR K.MACK 3/90
CHK C.GARCIA
DIV DIR M.STERN
DEPT HEAD
SATISFACTORY TO P.KANE
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

LMMSA

SKATE PAD, FENDERS, LINK TIE–DOWN

SIZE F CODE IDENT NO 80091 NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE SPEC SHEET 4 OF 4

IF IN DOUBT, ASK – DO NOT SCALE

J89–22(L650129)